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ABSTRACT

Recent developments in computer technology have resulted in the increasing presence of computers throughout society. As a consequence, schools must prepare students to make effective use of this technology. The purpose of this document is to provide administrators and teachers in the state of New York with guidelines for developing and coordinating the use of computers in mathematics in grades K-8. The booklet consists of five sections. The section on "Planning" emphasizes the importance of establishing a broadly based planning team to facilitate the development and operation of a school district's program that integrates computers in mathematics education. The next section, "Staff Development," discusses methods of coordinating and maintaining an ongoing staff development program. A section on computer hardware provides a brief description of the types of computers used in schools, with some considerations for selection. Another section contains an overview of computer programs, including how to assess and select software that meets the needs of mathematics education. The final section, "Teaching Mathematics with Computers," describes ways to use computers as effective aids for teaching mathematics. The appendices include lists of software suppliers, computer magazines, and software directories, along with considerations for using computers with students with handicapping conditions. (TW)

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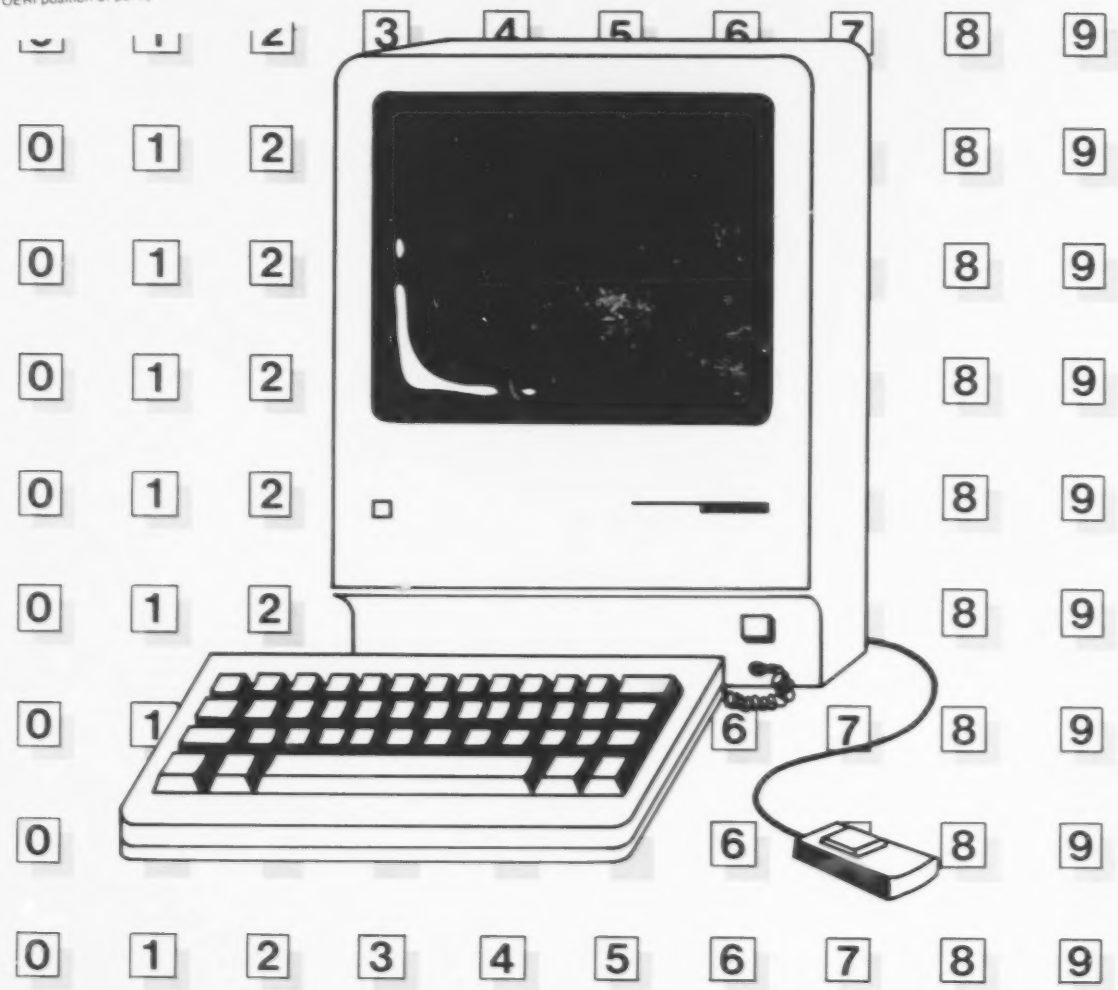
TEACHING MATHEMATICS WITH COMPUTERS

K-8



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The University of the State of New York
The State Education Department
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1987

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TO: Persons With Responsibility for Implementing Mathematics Programs, K-8

FROM: Edward T. Lalor, Director
Division for Program Development

Charles J. Trupia, Director
Division for General Education

The publication **Teaching Mathematics With Computers, K-8** is intended to assist educators in the use of computers to teach mathematics in kindergarten through eighth grade. The publication addresses planning, training instructional staff, acquiring hardware and software that is appropriate for the instructional program and students, and ways to use computers and computer programs effectively in the teaching of mathematics.

This publication has been sent to principals of public and nonpublic elementary schools, directors and coordinators of curriculum and instruction, elementary classroom teachers, elementary mathematics team teachers, teachers of seventh and eighth grade mathematics, directors, coordinators, supervisors and department chairpersons of mathematics education, and directors and coordinators of instructional technology.

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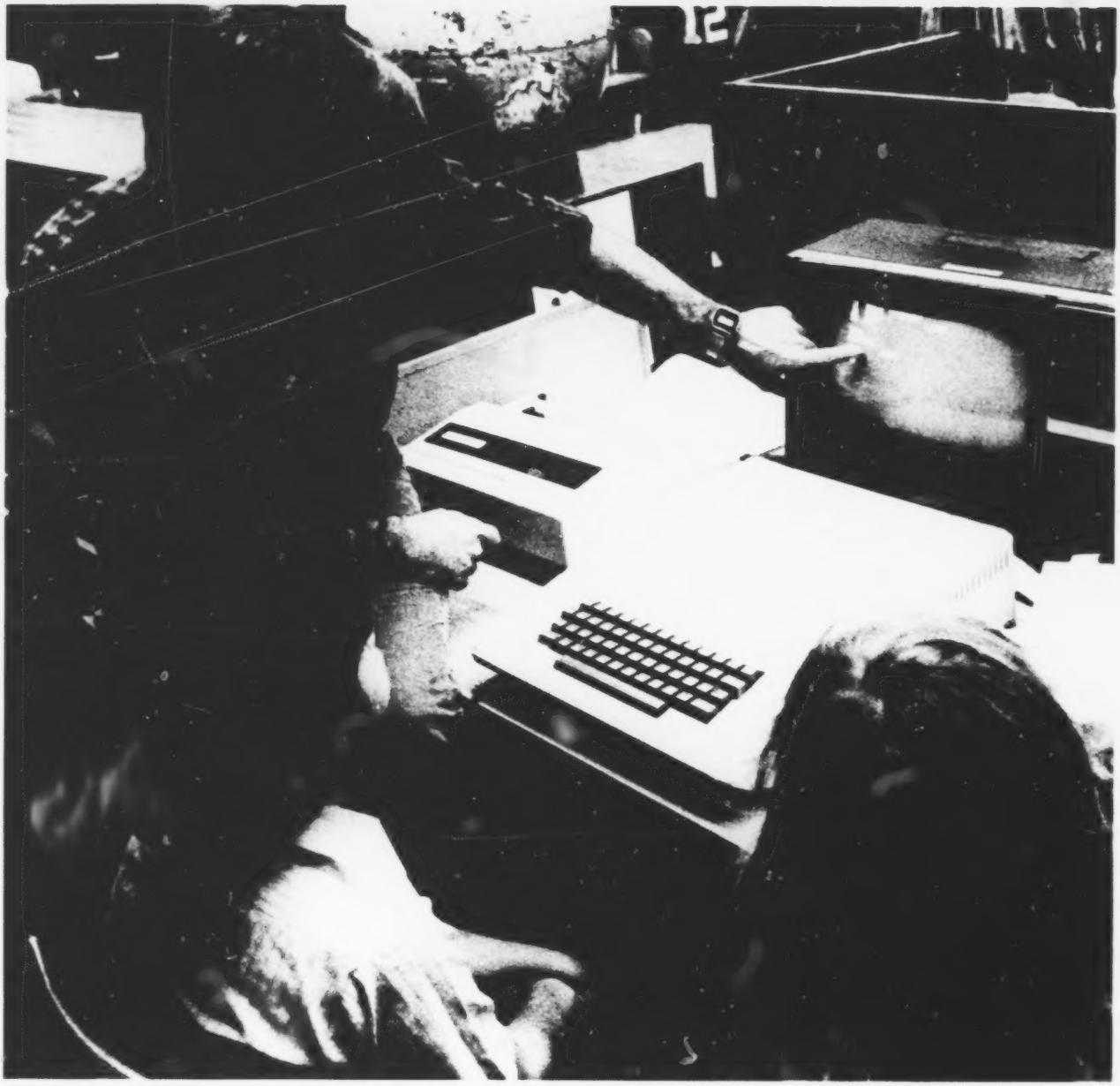

TEACHING MATHEMATICS WITH COMPUTERS K-8

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FOREWORD

Recent developments in computer technology have resulted in the increasing presence of computers throughout our society. As a consequence, our schools must prepare students to make effective use of this relatively new technology. It is with this statement in mind that this document was written.

In their Action Plan to Improve Elementary and Secondary Education Results in New York, the Board of Regents recommends that elementary education curricula be updated to incorporate computer literacy and computer technology into appropriate subject matter areas. They specifically recommend that students in grades K-8 acquire the skills necessary to use computers for problem solving, and that programs and materials incorporate a multicultural perspective into the teaching of mathematics.

The purpose of TEACHING MATHEMATICS WITH COMPUTERS, K-8, is to provide administrators and teachers with guidelines in developing and coordinating the use of computers in grades K-8. This publication is not expected to answer all questions that one might have, but it should provide direction, particularly for the classroom teacher, in using the computer as an instructional tool.

The manuscript for this publication was written by George H. Ropes and Shiela Swett, mathematics educators who specialize in computer applications, under the supervision of Benjamin H. Lindeman, Associate, Bureau of Mathematics Education, and Carol Anne Stiglmeier, Associate, Bureau of Curriculum Development. This manuscript was reviewed by staff from the Office for Education of Children with Handicapping Conditions in light of the needs of students with handicapping conditions and by the Office of Civil Rights and Intercultural Relations. Pictures were provided by Algonquin Middle School, Averill Park, New York; Chestnut Hill Elementary School, Liverpool, New York; and Columbus Elementary School, Mt.Vernon, New York. The contribution of all who helped in the development of TEACHING MATHEMATICS WITH COMPUTERS, K-8, is greatly appreciated.

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INTRODUCTION

More than one million microcomputers are now being used in elementary and secondary schools in the United States. More will be added every year. The total number of computers is, of course, an inadequate measure of the educational impact of this new teaching instrument.

Of greater importance is the question, "How can teachers use computers most effectively to teach mathematics concepts in grades K-8?" The information herein will provide a variety of ways to answer that question.

This publication consists of five sections:

- PLANNING – the importance of a broadly based planning team to facilitate the development and operation of a school district's program that integrates computers in mathematics education
- STAFF DEVELOPMENT – methods of coordinating and maintaining an ongoing staff development program
- HARDWARE – a brief description of the principal types of computers and related equipment used in schools; considerations to be taken into account when purchasing computer hardware
- SOFTWARE – an overview of computer programs, including how to assess them and how to select those that meet the needs of mathematics education
- TEACHING MATHEMATICS WITH COMPUTERS – ways to use computers and computer programs as effective aids for teaching mathematics from kindergarten through grade 8

A series of appendixes lists sources of information of interest to those using computers in their classrooms.

USING THIS GUIDE

READ "Planning" if you are:

- on any computer committee at your school.
- a computer coordinator.
- redesigning curriculum to integrate technology.
- interested in bringing about change in your school's policies or practices related to the effective use of computers.

READ "Staff Development" if you:

- have an interest in expanding your computer knowledge.
- are concerned about the computer training courses your school offers.
- work as an adviser or trainer of other teachers.

READ "Hardware" if you are:

- on a committee to recommend what computer equipment your school should purchase.
- thinking about purchasing a computer of your own.
- interested in increasing your computer vocabulary.
- in the market for a device to augment the capabilities of your computer.

READ "Software" if you:

- teach mathematics at any level from K through 8.
- want a good argument for buying a home computer.
- have a vote on the software your school orders.
- want to find good software for your own use.

READ "Teaching Mathematics with Computers" if you are:

- a math teacher at any level, with or without previous experience with computers.
- interested in programs that will enable you to do more or have more fun on a home computer.

PLANNING

The use of computers as an integral part of instructional programs is becoming more prevalent in elementary and secondary schools. Five years ago only a few schools serving grades K-8 had computers. The option to purchase hardware and software is becoming more feasible, and administrators and teachers must make difficult decisions related to the most effective uses of the technology to achieve curriculum goals.

Many schools have recognized the value of a committee made up of administrators, classroom teachers, special education teachers, curriculum coordinators, librarians, a computer expert, and other school staff to make key decisions about the ways computers will be used in the school. Mathematics teachers, because of their background and experience, have made and will continue to make valuable contributions on planning committees.

Planning and teamwork continue to be vital and necessary components of any curriculum development project, and school districts should be engaging in planning efforts to develop instructional programs that integrate computers into subject area curricula. Listed below are some of the concerns that confront a planning committee today.

- The development of a philosophy, goals, and objectives that relate to the instructional program and the needs of the students
- Equity of access to computers for all students
- Goals and objectives that include multicultural understandings
- The proper division of effort among computer literacy, computer programming, and using computers as part of the instructional program
- Procurement and allocation of hardware based on the purposes for using computers
- Selection of software that is of high quality and nonstereotyped by gender, culture, etc.
- The budget
- Ongoing curriculum and staff development
- Defining the role of the computer coordinator
- Evaluation, review, and revision of curricula

The Mathematics Teacher's Role in Planning

Mathematics teachers can contribute extensively to a school's program planning efforts by sharing information received at computer and/or mathematics conferences. In addition to learning about progress that other school districts in the state and throughout the nation are making, mathematics teachers can view and test a variety of new equipment that provides improved graphics capabilities, that enables use of computers by students with special needs, that provides networking capabilities within one classroom and among classrooms, and that enables interaction between video and computer.

Those who teach mathematics can keep abreast of new software as it is issued and recommend additions to the school's software library. Mathematics teachers who have a background in statistics or who have carried out a research project can render valuable service in any in-house evaluation of computer education that is undertaken, whether formal or informal.

The mathematics teacher is in a position to suggest possible improvements to the curriculum to employ computers in the teaching of mathematics in the best way. Some mathematics educators believe that the growth of computers will reduce the amount of time children spend doing pencil-and-paper operations like long division.

Keeping Abreast

Those involved with planning need to have access to many sources of information and expertise. Some of the many resources which may be tapped are:

- Computer personnel at nearby schools and colleges
- The nearest Board of Cooperative Educational Services (BOCES)
- The New York State Education Department's Center for Learning Technologies
- The Regional Computer Center in your area
- The nearest Teacher Resource and Computer Training Center
- The nearest Special Education Training and Resource Center (SETRC)
- Books, magazines, and newsletters (Pertinent periodicals are listed in Appendix B.)
- User groups, particularly one which focuses on a make of computer that is extensively used in the school
- Conventions sponsored by local, state, and national mathematics associations and other groups, such as the Association for Educational Data Systems

STAFF DEVELOPMENT

Teachers are the single most important factor in the effective use of computers in the classroom. Teachers must be knowledgeable about the potential uses of the technology to make important decisions related to the uses of computers.

Teacher training is one of the most essential areas and at the same time one of the most challenging issues in computer education and in the application of computers to the learning process. Few teachers except those who recently graduated from college have had instruction in computer technology. Developing the skills needed to teach about or with computers requires comprehensive staff development on a continuing basis.

There is more than one right way to learn how to use computers effectively.

Three common methods for learning to use computers are:

1. Self-teaching

   Many teachers have developed their computer skills by having a computer at home and teaching themselves from available books and manuals. Schools often encourage teachers to take a computer home for a weekend or vacation period.

2. In-service Training

   School districts frequently offer computer training sessions and workshops for their faculty. Some are conducted by a district computer coordinator or by a knowledgeable consultant engaged by the district.

3. Off-campus Courses

   These may be offered by the nearest BOCES, a Regional Computer Center, the Teacher Resource and Computer Training Center serving your area, the nearest Special Education Training and Resource Center (SETRC), or a local college. Both the New York State Education Department's Center for Learning Technologies and the National Council of Teachers of Mathematics offer excellent computer courses for teachers.

A combination of the above approaches is highly recommended. Computer training needs to be ongoing; a single training experience is rarely sufficient.

The content of introductory computer courses for those who teach mathematics should regularly include:

- Training in operating the computer and its peripherals, with plenty of hands-on time and no more than two persons per computer
- Exposure to a broad selection of the latest and best software in the area of mathematics, plus experience in evaluating mathematics software
- Techniques for correlating the use of computers with the New York State mathematics syllabi for K-6 and 7-8 whether in a classroom with one or two computers or in a computer laboratory
- Developing familiarity with the use of utility programs for word processing, student record keeping, grade keeping, and the designing of electronic data bases and spreadsheets
- Familiarity with a programming language such as LOGO or BASIC
- Using an authorizing system to develop software programs that address individual student needs without knowledge of programming

After completing an introductory course, teachers may go on to intermediate or advanced courses which pursue the topics listed above in greater depth.

Three courses frequently offered and of particular interest to teachers of mathematics K-8 are:

1. LOGO – a language that encourages step-by-step thinking, develops problem-solving strategies, and promotes mathematical thinking. LOGO is being used in mathematics programs at the elementary level to help students develop thinking skills using geometric concepts.
2. BASIC – a language frequently taught in schools in which students learn to write a simple program to perform a mathematical operation such as finding greatest common factors. Students must sequence the steps logically and be able to locate and eliminate errors. In the process they develop thinking skills as well as a broader understanding of the mathematical algorithms involved in the operations.
3. Using electronic spreadsheets – for problem solving, working with money and formulas, making predictions, and playing with numbers in novel ways, spreadsheet programs can be useful for students in fourth grade and higher.

Resources Required

Effective teacher training requires administrative support, a commitment of faculty time, and an adequate budget. Unless these resources are available, the hoped-for goals may not be achieved.

Teacher training also requires an understanding instructor. Every instructor of a computer course should remember, that to many other teachers, computers are strange and intimidating. It is important to build a positive attitude and instruct with patience, understanding, and humor. Instructors of introductory or general courses should concentrate on presenting ways for teachers to integrate the use of computers in their own classrooms, using mathematical concepts appropriate for each teacher's classroom situation.

The Computer Coordinator's Role in Training

In districts where there is a computer coordinator, the extent of his or her responsibility for working with classroom teachers should be made clear. If this is one of the coordinator's functions, planning time between the individual classroom teachers and the computer coordinator must be available. See Appendix D for sample job description for a computer coordinator.

All too often, coordinators find that scheduling and teaching computer classes to students, plus managing the software-hardware purchasing and repairs, is a full-time commitment that leaves little or no time for working with teachers. Some schools have a full-time computer coordinator whose role includes all computer-related responsibilities except teaching, a function performed only by regular classroom teachers.

A full-time commitment on the part of a computer coordinator is necessary to implement a comprehensive school computer program. Such a program includes giving support and training to regular and special education faculty, supervising any computer teachers, evaluating software to match each teacher's curriculum, and conducting awareness sessions for school board members, parents, and community groups. Released from daily teaching commitments, the coordinator can attend conferences, visit other schools, attend to computer repairs, participate in other off-campus job-related activities, and act as the primary resource person in the district for technology-related applications.

The Role of Mathematics Teachers

In many schools computers were first introduced in mathematics classrooms. Mathematics teachers, recognizing the computer's potential as a powerful educational tool, worked on their own and took courses in order to become more proficient in using the technology in the classroom. Consequently, mathematics teachers were often placed in leadership roles, and they helped establish school policy related to computer use.

Importance of Learning to Program

Because high quality software for use in mathematics classes is becoming more common, teachers no longer have to write programs for their own use. Therefore, the need to learn programming skills is lessening. Nevertheless, programming as a means of strengthening overall mathematics, computing, and problem-solving skills has proven beneficial for many teachers. This will be discussed further in the section, "Teaching Mathematics with Computers."

HARDWARE

As used in this section, the word "hardware" refers to computers and all the equipment and devices that may be connected to them.

The hardware on the market is constantly changing. Older computers are being discontinued; new and improved models are appearing. Rapid improvements are being made to "peripherals," i.e., equipment attached to or used with computers. More and more new and improved "add-on" devices are being offered for the more popular makes of computers. Comments in this section are divided into three categories: basic equipment, add-on equipment, and advanced equipment. Teachers at the elementary school level will be concerned primarily with basic equipment and some add-ons. Junior high teachers and those using computer laboratories will normally be concerned with all three categories.

A variety of special keyboards, monitors, and other peripherals are available to make computers accessible for persons with disabilities.

Basic Equipment

"Basic equipment" refers to computers, disk drives, and monitors; one of each is required for using computers for instructional purposes. The disk drive stores and loads programs; the monitor contains the computer's display screen.

No one computer can be recommended above all others. A school's decision on what computer to purchase is determined by many factors, including funds available and the school's curriculum goals. The principal considerations when buying computers for the first time or when adding to the school's existing computers are:

- **Amount of high quality educational software available**

  This is an extremely important consideration. Without high quality software, a computer, however powerful, is severely limited as an educational tool.

- **Size of computer memory**

  A computer's memory is measured in "bytes," the space required to store a single character. Today, virtually all computers have at least 48,000 (48K) bytes of usable memory. This is sufficient for most software programs. However, some current software requires 64K bytes and some requires 128K bytes. In the future, the number of programs requiring memory of 64K bytes or more will surely increase, particularly programs for use in mathematics education.

  Recommendation: When possible, purchase a computer with 128K memory or one that can be expanded to 128K. A computer with 64K memory may not be too limiting, but this should be the minimum for any new computer purchase.

- **Graphics capability**

  "Graphics" refers to the display of dots, lines, shapes, figures, or illustrations on the computer screen. Graphics are important to mathematics teachers for screen display of geometric shapes, manipulative materials, and large-size letters and numerals.

  A good measure of graphics capability is the total number of dots that can be displayed on the screen at one time. Multiply the maximum number of dots that can be placed across the screen by the maximum from top to bottom. The product gives a means of comparison. The greater the number of dots (sometimes called "pixels"), the higher and better the "resolution;" the smaller the number, the lower the resolution.

  In general, the higher the resolution, the fewer the number of colors that can be assigned to a particular screen area. Higher resolution allows for greater detail and better appearance. For example, with high resolution curved lines appear smoother (less like sets of straight lines) than with low resolution.

- **Monitor**

  The principal question is, Shall the monitor have color capability? It is easier to read text material displayed on a monochrome (black and white or green monitor) than on a color monitor. Therefore, when the computer output is primarily text, as for example with word processing, a monochrome monitor is preferable. The choice between black and white and green is one of personal preference.

  Except in word processing applications, color monitors are recommended. Color is a particularly important feature of software for grades K-4. Color monitors currently cost $200 or more; monochrome monitors cost from $89 up. A few monitors are capable of either color or monochrome display.

If exceptionally good color reproduction is essential, it is worth the additional cost to acquire an RGB monitor. Such a monitor uses a special electronic technique and costs $365 or more.

- **Disk drives**

  The standard for educational computers is a floppy disk 5 1/4" in diameter. Some computers come with separate disk drives; others have built-in disk drives.

  In a group of computers, it is extremely useful to have one or more equipped with a second disk drive. Some programs require the use of two disk drives. Also, having two drives makes it easier and quicker to make a copy of a disk.

  As discussed in the "Software" section, two other types of disks are available, 3 1/2" disks and hard disks. Programs on 3 1/2" disks require computers equipped with disk drives to run them. Hard disks and hard disk drives are primarily for administrative computer applications.

Add-on Equipment

- **Printers**

  After the computer, disk drive, and monitor are in place, the major item to be added is a printer. Printers transfer information from the computer screen or memory to paper. A cable connects the printer to the computer.

  Printer prices have decreased to the point at which it has become common for schools to have one printer for every three or four computers.

  A printer is indispensable for word processing. It is also valuable for giving students copies of their work, for preparing mathematics worksheets, and for use with the many programs that provide students and teachers with printed output.

  Quality color printers, once found only at commercial or business enterprises, are becoming affordable for special school applications. They add a whole new dimension to the learning process and are very effective when combining art and mathematics applications.

  There are two principal types of printers: dot matrix or daisy wheel. A third type, the laser jet printer, has just entered the market. For most school uses, a dot matrix printer is fully adequate. More expensive daisy wheel printers are used only when exceptionally high quality appearance is desired. Many current dot matrix printers provide a quality of printing similar to that of daisy wheel printers.

  To print computer graphics, printers need to be equipped with a "grappler" or other special device. All printers purchased for schools should have such a device.

  Another device called a "tractor feed" enables the user to load individual sheets of paper. Without a tractor feed, the printer uses continuous paper with side-strips that are hole punched. A pin-feed mechanism advances or retracts the paper.

  When a printer is attached to a computer, it takes a little time and effort to detach it and connect it to another computer. When a printer needs to be used with more than one computer, a switch box saves time and adds convenience. With such a box, a printer can be switched from one computer to another by the turn of a knob.

- **Memory expansion**

  Expanding the memory of a computer makes it possible to utilize programs that require 64K, 128K, or more memory. The memory expansion is provided by a card inserted within the computer.

  Apple IIe users may choose to have the computer "enhanced." An enhanced Apple IIe has 128K of memory. It also runs all programs written for the Apple IIc computer.

- **Joystick**

  A growing number of programs, particularly graphics and game-oriented programs, function better when a device called a joystick is attached to a connector at the rear of the computer. The joystick enables a user to move the cursor or an object on the screen in any direction.

- **Mouse**

  A mouse serves much the same purpose as a joystick. Moving the mouse on a flat surface produces a corresponding movement of an image on the computer screen.

  For computers to be accessible for all students, peripherals may need to be added such as magnification screens, expanded keyboards, special switches, etc.

Advanced Equipment

In addition to the basics and add-ons described above, a broad range of computer-related equipment is available to provide special features and add special capabilities to computer facilities in schools. Today's advanced features will tend to become commonplace in the very near future.

- **Network controller**

  A computer network is a system that enables a group of computers to function together. A program loaded in the "host" computer appears on each of the units in the network. A network controller is the device that makes the hookup possible.

  Considerable savings are possible through networking. Two disk drives will suffice for a network of 10, 12, or more computers. Fewer copies of software are required.

  It should be understood, however, that not all programs run on a computer network. Software publishers commonly supply programs that can be networked for an extra charge over and above the cost of a single program. A cost analysis of hardware and software is recommended before purchasing a networking system.

- **Modem**

  A modem is a device that enables a computer to be connected via telephone lines to another computer or to an outside source of information or data. A modem and the software to use with it cost a minimum of $200. Currently the use of modems in schools is relatively infrequent because of the high costs of telephone charges and high rates for each minute of connect time to the data source. However, there is every reason to believe that the use of modems will increase in the future as costs decrease. The educational potential of access to libraries and to data banks of all kinds is enormous.

  For an hourly charge of approximately $12.50 during daytime hours, or $6.00 at night, a school's computer can be linked via modem to a commercial information source. News, stock prices, weather, banking, games, and electronic mail services are available. Though not widely used in grades K-8, those who have experimented with this form of telecommunications recognize its potential for tapping new sources of information.

- **Plotter**

  A plotter is a specialized device capable of producing multicolor graphs, charts, and complicated designs on paper.

- **Videodisk/computer hookup**

  The technology is currently available to combine the facilities of television and the computer. Videotape or videodisk can be tied through software to a computer in such a way that, at appropriate intervals, action switches from the videotape or videodisk to the computer for a series of questions to be answered by students.

  In the future, educational television programs may be available to school via satellites, or through tapes to be run on videocassette recorder (VCR) equipment.

  Equipment costs and production costs are still high, but both are certain to drop as the market for these products grows. Existing programs in the form of videotape, videocassette, or videodisk can be used, but planning time is required for creating the lessons on the computer to accompany the video.

Cost and Servicing of Hardware

Since the first computers entered schools, costs have dropped continuously and the power, speed, and overall capabilities of computers have increased many times over. There are strong reasons to believe that both trends will continue – that costs will decrease and capabilities will improve.

Those purchasing computer equipment should keep these general rules in mind:

1. Know exactly what you want the equipment to do.
2. Get prices from several suppliers, preferably authorized representatives of the manufacturer.
3. See if the item is on New York State contract. Remember that occasionally a supplier will quote a price under the State contract price.
4. Get opinions of others who have used the equipment you are considering.

Although the need for repairs or servicing arises fairly infrequently, when service is needed, it is highly desirable to have a nearby organization to handle the repair. Many schools have found that paying for repairs as incurred is less expensive than buying annual maintenance contracts.

SOFTWARE

Growth in Quality and Quantity

For years, critics have pointed to the lack of good software as a major stumbling block in the path of educational computing. Until fairly recently, the observation was valid. However, a gradual change has taken place. The amount of software for educational purposes is growing and, in addition, the quality is improving. Also, textbook publishers are beginning to produce software and to correlate it with their current mathematics textbooks.

New programs often use advanced programming techniques and take advantage of the large memory capacity of the latest computers. There are several hundred computer programs in the K-8 mathematics curriculum area. Roughly 80 of these are mentioned in this section and in the section, "Teaching Mathematics with Computers."

Publishers' Concern for the Education Market

Publishers' products reflect an increasing concern for the needs and views of mathematics teachers and students. New programs are more likely to fill an educational need than merely to cover an easy-to-program topic. Educational know-how and technical excellence are being combined to improve the final output.

As a result, when ordering software, schools can now anticipate:

- a 30-day approval prior to purchase
- back-up disks, teacher manual, and student worksheets
- an option to purchase multiple copies at a discount under the single copy price
- special disks capable of being used in computer networks

Some software publishers and distributors are offering such additional features as:

- a toll-free telephone number to call should questions or problems arise
- a 30-day (or longer) warranty on all disks
- on-site demonstrations
- separate versions of a program for each major make of computer

Evaluating Software

Selecting the right software for each particular application is not easy. Software evaluation is very personal; a program that suits one mathematics teacher will not appeal to another. Those involved in choosing school software should look for programs that are:

- educationally sound
- easily understandable
- backed up by a clear, easy-to-read teacher's manual
- nonstereotyped in regard to sex, race, culture, disability, etc.
- simple to use – students may go easily from one part of the program to another, or back to the beginning
- interesting – students will want to use it again and again
- interactive

Features to look for in particular applications are the ability to furnish and analyze student scores, preferably on a printer, and the opportunity for teachers to insert their own problems or working data.

Those who teach mathematics may well look askance at a program in which there is:

- overemphasis on graphics to the degree that educational aspects are overlooked
- little but a textual presentation, thus underutilizing the computer's many other capabilities
- a surfeit of games that involve primarily manual dexterity

Besides the educational considerations that enter into the purchase of software, there are a number of technical questions to be addressed, including:

- Is a color monitor required? Many new programs, especially those directed at elementary students, incorporate graphic displays that are wasted on a black and white monitor.
- Is a special device such as a joystick, mouse, or Koala Pad required?
- Does the program require two disk drives?
- Will the school's disk drive match the software? The 5 1/4" floppy disk is standard for almost all educational software, but other sizes such as 3 1/2" are coming into use. For further information, refer to the section, "Hardware."

- Is the program compatible with the screen width of the existing computer(s) – i.e., 40 columns or 80 columns?
- Does the program require a printer?
- Will the software run on the make and model of computer available?

Principal Types of Software

Software for use with mathematics K-8 may be classified as:

Drill and Practice	Teaching Programming
Tutorial	Problem Solving
Diagnostic	Utilities
Simulations	

The principal characteristics of each type are set forth under the corresponding headings below.

• Drill and Practice

Any program whose primary focus is on drilling a specific topic, such as multiplication facts, falls into this category.

Drill is important, not to say indispensable, for learning the basic facts and many other routines of elementary and junior high school mathematics. The computer has proven to be a very effective medium for drill and practice. It is impersonal, tireless, and above all, highly motivating to students. Some computer-based drill and practice programs incorporate game elements; others use random number generators to present varieties of exercises; others provide timers and student scores. Although time-consuming, care should be used in selecting drill and practice programs.

• Tutorial

Using the computer as a tutor, with software that teaches a given topic step-by-step and progresses at the user's rate of learning, can be extremely effective. Many programs purport to be "Computer Assisted Instruction," but those which are tutorial in the best sense of the word are few.

Tutorial programs have great potential to help mathematics teachers. They can help students who have missed classes or who need more time reviewing a particular topic or area. A gifted child can use a tutorial program to investigate an advanced topic. A student in a Resource Room may complete a variety of IEP objectives at his or her own speed, in private, at the computer.

The ideal tutorial progresses at the speed of the student, branching according to his or her responses. Where there is a built-in management system, the student may finish part of a lesson at one time and then come back later to continue working on it. Good tutorials require student interaction; most use graphics extensively. Where there is a game, it is placed after the main content of the tutorial, to serve as a reward.

Several programs that do word processing, set up spreadsheets, make graphs, or organize data bases are now being provided with built-in tutorials. These make it easy for students (or teachers) to learn to use the programs. Often the tutorial comes with samples or specimens to familiarize the user with the details of the program.

Some may question whether tutorial programs may be developed to the point at which they impinge on the role of the teacher in the classroom. The likelihood is that, however expert tutorial programs become, the importance of the teacher will be augmented by the computer, not diminished. A teacher who uses one tutorial with several students will be able to share the time saved by giving more personal attention to other students.

• Diagnostic

A computer program that tests and evaluates students, diagnosing specific errors and prescribing a personalized remedial course of action, has the potential of making a major contribution to education.

At present, there are only a few diagnostic programs in the area of K-8 mathematics. Techniques are being developed to overcome the difficulties of analyzing and prescribing for the large number of possible errors that may arise in students' work. Diagnostic programs are one of a class of programs known as "Expert Programs" or "Artificial Intelligence."

A substantial increase in the number and scope of diagnostic programs is likely in the future. Current examples include *Math Assistant I* and *Math Assistant II*, both by Scholastic, Inc., and *Magic Cash Register*, by Avant Garde. More details of these programs will be found in the next section.

• Simulations

A simulation program is one that puts the student in the position of taking part in a historical or imagined experience. Students may simulate traveling with a covered wagon train in *Travel to Oregon* or running a modern lemonade stand in *Lemonade Stand*.

Although simulations are most useful for extending students' knowledge of history, geography, or science, there is almost always a place for using mathematics. The better simulations are ideal ways to integrate mathematics with science, language arts, and social studies.

Because simulations require considerable advance planning, some teachers may be hesitant to use them. The fact that the focus tends to be general (multidisciplinary) rather than specific to one discipline can also be a

deterrent. Nevertheless, teachers who have used simulations point to a marked strengthening of students' learning skills, particularly note taking, strategic thinking, decision making, and manipulation of real-life data.

Classroom learning can be extended in new and challenging ways, "living" situations never before possible in schools.

- **Teaching Programming**

There are two varieties of software programs to teach programming. The first is a software program that is itself a programming language; the other is a software program that teaches the user how to program in a language that is built into the computer.

The most common example of the first kind is LOGO. The LOGO language is used extensively by students from grades 2-6. Instances of use at earlier or higher grades are much less common.

Thousands of students have become familiar with LOGO's Turtle Graphics and have used them to create geometric figures of all degrees of complexity. Some versions of LOGO include "sprites" (shapes that may be given color, direction, and speed). As students progress in their use of LOGO, they learn a great deal about angles, rotations, distances, coordinates, and other mathematical concepts. They also develop problem-solving and critical thinking skills.

Several software programs, often referred to as pre-LOGO programs, help students from kindergarten through second grade develop skills such as sequencing, estimating, directionality, and following directions so that they can move on easily to LOGO. Two such programs are *EZ-LOGO* by M.E.C.C.and *Delta Drawing* by Spinnaker. Not a software program but a programmable mechanical toy, BIG TRAK works very efficiently as an introduction to early learning and programming skills. Note: BIG TRAK is no longer manufactured. *Turtle Tot* by Harvard Associates or *CompuRobot* by CompuTech Systems may be used instead.

The second type of software program to teach programming is not in itself a computer language, as LOGO is, but rather a software program that teaches students how to program in a language already found in most computers. Software programs that teach programming in BASIC are quite common. Most are correlated with a textbook.

In the early days of school computing, teaching BASIC typically began in upper elementary grades. That is changing. Today, teaching BASIC frequently starts at seventh grade and works well with those junior high students who have a definite orientation toward computers.

- **Problem Solving**

The primary purpose of some software programs is to develop students' thinking skills. They put learners in situations in which they analyze data, make educated decisions, and are led to think through each response. These problem-solving programs are not aimed at doing traditional word problems. They deserve a place in the math curriculum because they provide new ways of teaching the use of logical thinking to solve nonroutine problems.

As do simulations, problem-solving programs often require time – both class time and teacher preparation time. Because these programs are best used by teams of students and, given the tremendous importance of developing students' problem-solving skills, teachers will need to give special consideration to fit them neatly into the standard mathematics curriculum.

- **Utilities**

Utility programs – also called "tool" programs or "applications" programs – perform useful functions or tasks.

Word processing programs make writing, editing, and report writing easier.

Graph-making programs bring new excitement and understanding to picture, bar, pie, and line graphs. Students, often for the first time, have a way to create and present graphs with a professional look, graphs that provide visual comparisons for data in science, history, or other curricular areas.

Spreadsheet programs, originally created as an aid to business, are turning out to be an excellent way to give presecondary students interesting problem-solving experiences. They allow users to organize words, numbers, and mathematical formulas into rows and columns, and to manipulate data in an enormous variety of ways. Spreadsheets are the single best tool to enable a user to answer the question "What if?"

Data base management programs allow students to store, modify, access, sort, and analyze data on virtually any subject. Such a program may, for example, store population and census data for a number of countries around the world. Students can then compare population densities, growth rates, median ages, or other mathematically related topics.

The utility programs described above came into being separately. A recent trend is for publishers to combine several types of utility programs into one multipurpose program. For example, *Apple Works* from Apple Computer enables one to do word processing, spreadsheet work, and data base management by using both sides of a single disk. A combined program, though costly, is

generally less than one would pay for individual programs that carry out the same three functions.

Several less sophisticated utility programs "perform tasks for their users." For example, mathematics vocabulary can be put into a crossword puzzle through Mindscape's *Crossword Magic*. A game show with content at any desired level can be created through *Tic Tac Show* from Advanced Ideas.

One of the most exciting newcomers in the field of special purpose programs in the mathematics field is the *Geometric Supposers* series from Sunburst. These programs enable a student to place points and lines on the screen and to combine them into triangles or quadrilaterals. The computer can be called on to measure lengths of segments or angles, to bisect angles, to erect perpendiculars, and in general to give the student the ability to experiment with geometric relationships.

There are programs that use an analytic approach to promote the solving of word problems, problems with gear ratios, problems making change, and problems with filling storage tanks.

Programs that perform particular tasks can be extremely useful tools for mathematics teachers in grades K-8. Open-ended and flexible, they can bring new dimensions and new success to mathematics teaching. Acquiring the skill to use the great bulk of the currently available utility programs should not require a teacher to take an additional course or courses. An hour or two at the computer alongside a person who is already using a program should be enough for most teachers.

Courseware Selection

Each type of software has its own positive features. The variety of software programs currently available provides vast possibilities for every mathematics teacher from kindergarten through eighth grade. Choosing the appropriate software means matching what is available with the mathematics curriculum, with the style and experience of the teacher who will use the program, and with the learning styles and experiences of the students.

Certain programs are better when used in a classroom setting; others are ideal for a computer laboratory geared to class-size groups. Some programs are appropriate for highly motivated students, others for students with less motivation and liking for math.

Information about Software

A number of ways to obtain information about software are listed below. The best recommendation is to use several of these sources. It's important to remember that the software picture is constantly changing; efforts to keep up-to-date need to be ongoing.

1. Study commercial software catalogs in the files.
2. Read educational computer magazines in the school library or the public library. Refer to Appendix B.
3. Talk to the person who orders software for your school.
4. Consult with the nearest BOCES, the Teacher Resource and Computer Training Center serving your area, the nearest Special Education Training and Resource Center, or the New York State Education Department's Center for Learning Technologies.
5. Talk to other teachers who work with computers.
6. Attend educational computing conferences.
7. Join a group of educational computer users in your area.
8. Refer to a published compendium of software reviews. Examples are given in Appendix C.
9. Get software on approval from publishers.

TEACHING MATHEMATICS WITH COMPUTERS

Computer education has been described as having three major parts: teaching about computers, teaching how to program computers, and teaching with computers.

Teaching about computers is becoming of less concern since masses of children have become "computer literate" from past teaching or from having a computer at home.

The need to teach programming is diminishing, in part because of the availability of adequate software, and in part because of the realization that only a small fraction of the student population will become programmers.

Today, helping students learn with computers is the main emphasis of computer education. A teacher with little or no previous computer experience can easily play a valuable role in this process. Three first steps are:

1. Developing goals and objectives for the mathematics program that integrate the use of computers.
2. Identifying the software programs that would be best suited to the instructional program and the needs of the students.
3. Learning how to use the hardware.

Location of Computers

There are a variety of options for locating computers: in a computer laboratory, in classrooms, in the School Library Media Center, or in any combination of these locations. Naturally, the decision has an effect on how teachers integrate the computers into their teaching.

1. Laboratory Setting

   With enough computers for simultaneous hands-on time, a computer lab can provide total class participation. Often, a network links a group of computers to a master computer so each student can work on a common topic at his or her own pace. A computer teacher is usually in charge of the laboratory. This person should be available to assist students as they use the computers. Optimum success of this option usually requires planning and coordination between the classroom teacher and the computer teacher.

2. Classroom Setting

   With one or two computers in a classroom, a teacher can control when and how each computer is used. Commonly, each student has an assigned computer time. Optimum use of the computer or computers is promoted when there is a resource person who can advise on scheduling, suggest software, and help with any computer problems that arise.

There are several variations of the foregoing arrangements. Some schools have computers in laboratories, in classrooms, and in the School Library Media Center. Others move computers from one class to another on wheeled carts. Whatever the arrangement, there is need for planning and scheduling by a coordinator or a teacher with computer experience.

In primary grades, it is more common to have computers located in classrooms. Higher grades tend toward a laboratory setting and the School Library Media Center. Teachers generally view a combination of these as the ideal.

When a computer is placed in a classroom, there are many ways of positioning it. It may be placed behind a bookcase to prevent distraction or in the front of the classroom for whole class demonstrations. If a printer accompanies the computer, a back corner may minimize printer noise. If computer sound effects are a problem, the speaker may be disconnected.

Mathematics Software

Specific Programs Page 31

These pages list and describe independent mathematics software programs appropriate for students in kin-

dergarten through eighth grade. The listing is arranged by grade level and by mathematics topic. The charts are not all-inclusive; they are merely representative programs that are available. Opinions about appropriate software differ considerably, and teachers are encouraged to review these and other available programs before making a selection.

Each program is independent of any larger software package and hence is appropriate for use when there is but one computer in a classroom. Some teachers may want to create a chart for their own use, showing topic-by-topic the software that is available and that satisfies their needs.

Packages of Programs Pages 32-36

These pages list and describe series of programs spanning several grade levels and usually several mathematical topics.

Utility Software Pages 37-40

These are specific programs that perform "utility" functions as described in the previous section.

Games Pages 40-41

These pages describe the pros and cons of computer games and give examples of useful games.

Worksheet and Test Generators Page 42

These programs enable teachers to generate worksheets and individualized tests.

LOGO Pages 43-49

These pages describe how LOGO can be integrated into the mathematics curriculum; ways to introduce LOGO in the classroom are suggested.

BASIC Pages 50-51

This section supports an affirmative answer to the question, "Should programming in BASIC be part of mathematics classes?" Ways BASIC can and should be integrated into upper elementary and junior high math classes are illustrated.

One program from each topic area is described in depth. An attempt has been made to include programs from many publishers. It is not to be concluded that the programs chosen for in-depth descriptions are better than the others listed. It is merely illustrative of the grouping. Each program is relatively inexpensive and is independent of a larger publishing package.

KINDERGARTEN – FIRST GRADE
MATHEMATICS SOFTWARE

TOPIC				
NUMBER CONCEPTS	STICKY BEAR NUMBERS (Weekly Reader) Excellent animated graphics; child manipulates and controls number/quantity displays, can count up or back.	NUMBER FARM (DLM) Very basic, colorful and graphically motivating. Reinforces beginning mathematics and counting. Requires adult assistance.	NUMBERS (Lawrence Hall of Science) Counting, 1-1 correspondence, numerical and spatial skills, sorting, seriating. Reinforces hands-on activities.	COUNTING PARADE (Spinnaker) Colorful, imaginative 1-1 correspondence matching, counting and grouping jungle animals. Requires a joystick.
WHOLE NUMBER OPERATIONS (+ AND –)	THE SWEET SHOPPE (Heath) A display case "menu" of popcorn, ice cream, and jelly beans represents three games for adding and subtracting number combinations from 0-9 and counting from 0-9.	NUMBER STUMPER (Learning Co.) Use logic to add or subtract digits 1-9 to solve dice problems. Similar to the classic game of "Cover-Up."	FAY, THAT MATH WOMAN (Didatech) Fay jumps along a number line cheerfully, reinforcing each mathematics operation with animation.	STICKY BEAR MATH (Xerox) Adjusts to user's ability. It provides versatile, basic mathematics drills with graphics for reinforcement.
GEOMETRY	DELTA DRAWING (Spinnaker) Provides pre-LOGO activities – exploring geometric shapes, measuring, developing spatial awareness and directionality.	EZ-LOGO (MECC) Use with Apple LOGO for 1-key commands and follow simple tasks – mazes, tracing or copying letters.	TURTLE TOT (Harvard Assoc.) Floor turtle programmable in different languages. It attaches to a computer with a cord. Concrete and "real."	COMPUROBOT (Compu-Tech) Small, sturdy programmable robot replaces BIG TRAK but with smaller control panel. Three speeds, sound, light, and timer.
STATISTICS & MEASUREMENT	FISH SCALES (DLM) On-screen measuring stick helps players compare height, length, and distance while using colorful fish games.	MONEY! MONEY! (Hartley) Practice solving simple coin problems in a safe, sure manner. Can edit. Use with the real thing.	COMPARISON KITCHEN (DLM) Promotes visual discrimination and classification skills. Uses concept words such as less, more, same, different. Fun!	ESTIMATION (Lawrence Hall of Science) Three "thinker" games for introducing and playing with the concept of making intelligent "guestimates."
THINKING SKILLS	GERTRUDE'S SECRETS (Learning Co.) Attribute games manipulating colors and shapes to discover patterns and rules.	BUMBLE GAMES (Learning Co.) Plotting number pairs, naming positions in arrays and points on a grid while playing six cheerful games.	MOPTOWN PARADE (Learning Co.) Discriminate between attributes of Bibbits versus Gribbits to complete each puzzle. Six levels. MOPTOWN HOTEL (Learning Co.) Bibbits and Gribbits offer new challenges; more difficult than MOPTOWN PARADE.	THE POND (Sunburst) Guess variable patterns of frog jumps by trial and error plus logical deduction. Nice graphics.

Kindergarten – First Grade Mathematics Software
(see chart)

1. Number Concepts: *Sticky Bear Numbers* (Xerox/Field Pub.)
Number Farm (DLM)
Numbers (MCEP)
Counting Parade (Spinnaker)

The graphics of *Sticky Bear Numbers* are irresistible for pre-readers. They explore numbers and count forward and backward on their own to reinforce concepts introduced with concrete manipulatives. Press any keyboard digit and an exciting and random variety of animated pictures appears, along with familiar songs. Press the space bar, and count backward from that number to zero, or go forward to nine. The inclusion of zero is unusual at this level. Using the sequencing of numbers and visualizing a one-to-one number/object correspondence while controlling the speed of the presentation, the program motivates each student to play and learn without teacher supervision.

2. Whole Number Operations: *The Sweet Shoppe* (D.C. Heath and Co.)
Number Stumper (Learning Co.)
Fay, That Math Woman (Didatech)
Sticky Bear Math (Xerox)

Fay, That Math Woman reinforces addition, subtraction, multiplication, and division facts using numbers to eighteen. There are six options, four tutorials, and two games. Fay is a bouncy lady who illustrates each problem by hopping or leaping along a pictorial 1-18 number line. Given the problem 3 + 4 = 7, Fay will take three steps, pause, then take four more and arrive at seven. The combination of sound and animated graphics is excellent for younger children and is the next step after concrete manipulation of objects. Not too abstract, this program cleverly illustrates the process of each operation. The sound can be turned off, but it adds humor – Fay taps her foot while the user ponders. This program will also print any player's list of errors.

Teacher tip: Problems appear randomly, using any number combination between 1 and 18. Younger children might need their own number line or chips to work with various combinations.

3. Geometry: *Delta Drawing* (Spinnaker)
EZ-LOGO (MECC)
Turtle Tot (Harvard Assoc.)
CompuRobot (CompuTech)

Delta Drawing develops spatial awareness, left-right concepts, keyboard recognition, and computer confidence. The process of creating shapes or guiding the turtle/delta through preset mazes challenges and excites students as they gain valuable mathematical knowledge. Teachers observing students using this program can gain valuable diagnostic information about each student's understanding of fundamental mathematics concepts. *Delta Drawing* requires only single key programming input. Unlike LOGO, no two-digit numbers are required for angle turns, yet it captures the essence of "turtle geometry" in ways appropriate for students in kindergarten and first grade. Version 1.0 has embellishments which increase the creative possibilities. Printing out and coloring one's creation are both easy and rewarding.

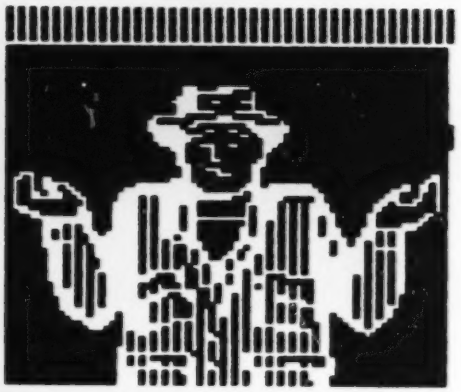
4. Statistics and Measurement: *Fish Scales* (DLM)
Money! Money! (Hartley)
Comparison Kitchen (DLM)
Estimation (MCEP)

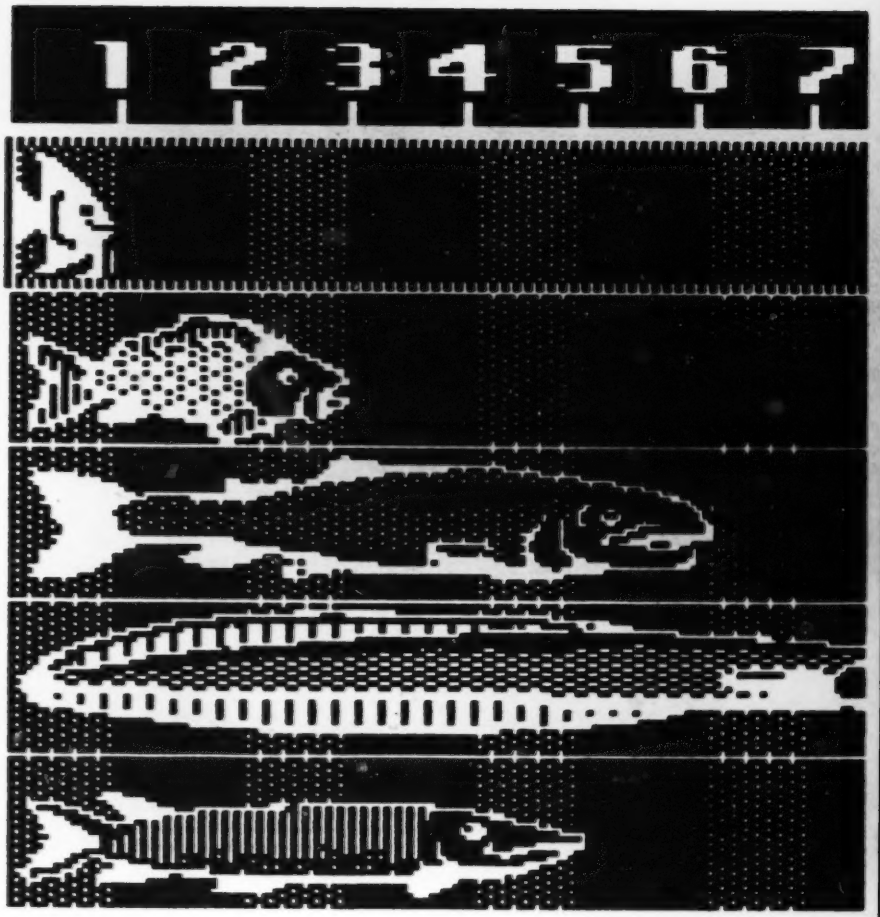
Fish Scales is an intriguing program with six measurement games of increasing complexity. Number as a function of size (height or length, distance on a number line) is basic to an understanding of mathematics. The concept is brilliantly presented in this program. A friendly fisherman guides the user through each fish game; an on-screen measuring stick reinforces the comparisons between a 2-fish and a 4-fish, etc. Sound effects are captivating, but they can be turned off for classroom use. This is a novel, catchy, and conceptually sound mathematics program ideal for students in kindergarten and first grade.

Teacher tip: Although it is a good idea to introduce the program to the class as a whole, it does not require teacher supervision. Students working in pairs can explore numerical concepts with skill-building results.

Which fish is five long?

Spacebar moves box. Then press RETURN.





Fish Scales (DLM)

5. Thinking Skills:

Gertrude's Secrets (Learning Co.)
Bumble Games (Learning Co.)
Moptown Parade & Hotel (Learning Co.)
The Pond (Sunburst)

Both the Learning Company and Sunburst produce software that forces the user to think, to analyze the givens, and to make decisions based on visual data.

Most primary classrooms have a collection of attribute materials that teach children to discriminate between specific characteristics such as shape, color, or size. Now the computer brings the child a step away from the purely concrete with programs such as *Gertrude's Secrets* and *Moptown Parade*. Moptown is inhabited by two kinds of creatures, Bibbits and Gribbits. As players discover the differences and use this information to decide who's next in a series, they are developing visual discrimination skills while following directions and learning to use the computer keyboard.

In *The Pond*, a frog jumps in a randomly chosen pattern across a pond, from lily pad to lily pad. The student must discern the pattern of jumps and make the frog follow its guessed sequence. If wrong, splash! The frog moves randomly from left to right, OR right to left – the latter may not be optimal for younger children learning to read. Nevertheless, students must learn to look in all directions. Most board games, such as checkers, require multidirectional moves, as does *The Pond*. Its goal is problem solving, not reading.

SECOND – FOURTH GRADE MATHEMATICS SOFTWARE

TOPIC				
NUMBER & NUMERATION	MATH CONCEPTS I & II (Hartley) Reinforces most basic math concepts, from odd/even to primes. LCM or GCF, to rounding decimals.	NUMBER WORDS II (Hartley) Large, easy-to-read words to translate to their number equivalents, from 100 to 1,000,000. Add own.	PLACE VALUE (EME) Ones, tens, and hundreds concept is reinforced by using the chip-trading Dienes Blocks model. Tutorial and game.	ESTIMATION (MCEP) Three graphically interesting and mathematically appropriate estimating activities for younger children. Experiment!
WHOLE NUMBER OPERATIONS	ACADEMIC SKILL-BUILDERS (DLM) Six programs use arcade-game format to drill basic math facts. Kids love them. Can control speed/difficulty.	STICKY BEAR MATH (Weekly Reader) Twenty levels; can preset. Records progress, automatically adjusts, is versatile for drills (+,−).	FAY, THAT MATH WOMAN (Didatech) Fay jumps along a number line, reinforcing each math operation graphically. Animated drills.	PIECE OF CAKE (Springboard) Five math games reinforce basic math facts. Students solve problems in a bakery.
FRACTION/ DECIMAL OPERATIONS	FRACTION FACTORY (Springboard) Five games, multiple skill levels, visual – a safe, sure, useful tutorial with hints. Comprehensive.	MATH BLASTER! (Davidson) Complete tutor, drill, and game program for all 4 operations, + fractions, decimals. Can add own sets.	GROWGIN'S FRACTIONS (MECC) Interactive tutorials ordering fractions with like denominators or numerators. Control levels.	PICK THE NUMBERS (Heath) Provides ample practice for students learning to compare decimals and fractions. Two games challenge students to choose and correctly order fractions and/or decimals on a number line.
GEOMETRY	LOGO (Apple, MIT, etc.) "Turtle Geometry" involves user in active explorations of angles, linear measurement, estimating, etc.	BUMBLE PLOT (Learning Co.) Next level above Bumble Games; same format but requiring use of negative numbers. Six useful games.	THE FACTORY (Sunburst) Create or duplicate endless variations of geometric shape "products" while using factory assembly line.	COMPUROBOT (CompuTech) This small robot is similar to BIG TRAK (no longer made) in capabilities, but is a robot, not a tank.
STATISTICS & MEASUREMENT	SURVEY TAKER (Scholastic) A tool for creating, giving, and interpreting surveys on any topic, especially easy for classroom use. Bar graphs or tables display results.	USING A CALENDAR (Hartley) Practice answering a variety of questions while using the given calendars, or add your own. Useful drills.	THE MAGIC CASH REGISTER (Avant Garde) Electronic tool for working with money and reinforcing basic math skills. Error analysis.	EXPLORING TABLES & GRAPHS I (Xerox) Includes thoughtful tutorials, games, practice sessions. Can create and print your own graphs, too.
THINKING SKILLS	GERTRUDE'S PUZZLES (Learning Co.) Attribute challenges while you follow Gertrude's "rules" and solve logic problems.	GNEE OR NOT GNEE (Sunburst) Game of visual discrimination and rule formation. Examine two sets of shapes; some are "gnees" and some are not. Determine the rule.	PUZZLE TANKS (Sunburst) Fill or empty two tanks with different liquids to reach the target amount in storage tank. Game of numbers and logic.	INCREDIBLE LAB (Sunburst) Explore various chemicals to see how each one affects the resulting monster created dramatically on screen. Take notes, work in pairs, think!

Second – Fourth Grade Mathematics Software
(see chart)

1. Number and Numeration: *Math Concepts I & II* (Hartley)
Number Words II (Hartley)
Place Value (EME)
Estimation (MCEP)

Estimation, from the Lawrence Hall of Science at Berkeley, is a part of the series "Micros for Micros." Although originally designed for the primary grades, it can be a challenge for all ages. A thoughtful teacher's guide includes four estimation games to try "off the computer" as well as three games that present different ways to develop good "guestimating." A train moves into a tunnel and students must press the space bar when they think it has reached the arrow. Sound clues can be turned off/on, train speed can be varied; train visibility in the tunnel is another on/off option. In "Junk Jar" students are asked to choose an object and guess how many will fill a jar whose size varies randomly. "Bug Tracks" has three different sub-games: guess how many bugs will fit along a given line; guess which bug track is longer; draw a line matching the bug track (which is NOT parallel). Some students may have difficulty with the concept and will need varied opportunities for developing this vital mathematics skill.

2. Whole Number Operations: *Academic Skillbuilders* (DLM)
Sticky Bear Math (Xerox)
Fay, That Math Woman (Didatech)
Piece of Cake (Springboard)

Sticky Bear Math is an addition and subtraction program with twenty levels of difficulty. It automatically adjusts itself to each child's progress, an extremely useful but unusual feature in programs written for this age. Groups of objects aid in counting at the lower levels; five-place computing with carrying and regrouping is included at the top levels. Problems are presented both vertically and horizontally. Teachers can customize the program, and each child's progress is recorded so that students will always start the program wherever they last finished. These special options increase the value of this useful drill and practice program.

3. Fraction/Decimal Operations: *Fraction Factory* (Springboard)
Math Blaster! (Davidson)
Growgin's Fractions (MECC)
Pick the Numbers (D.C. Heath and Co.)

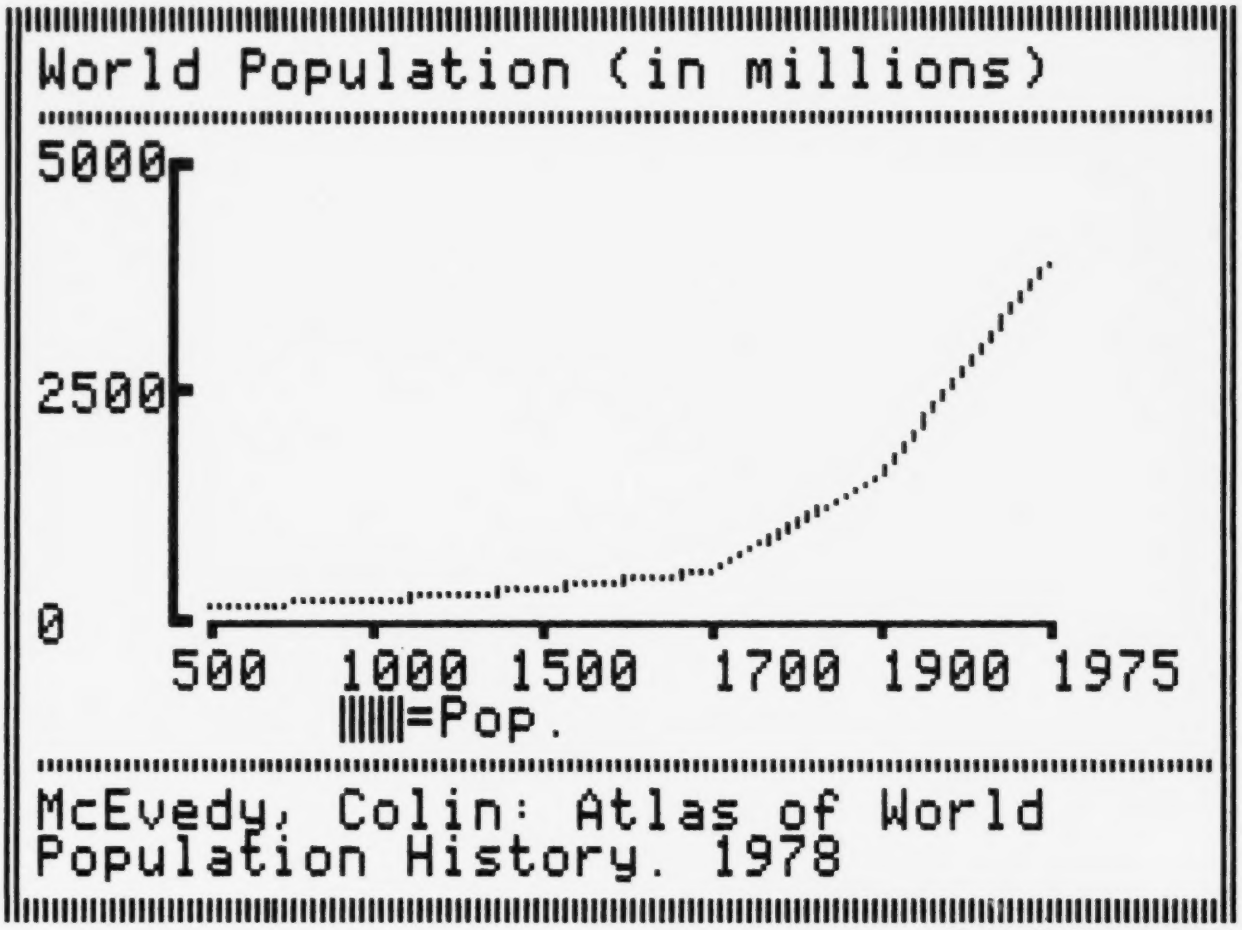
Fraction Factory is a comprehensive tutorial with five games and multiple skill levels that make it useful for students in grades 2-6. Using colorful graphics and musical sounds, this program helps students see and describe fractions, find equal values with different denominators, add, subtract, and multiply fractions. Because this difficult topic is on the computer, and because students can explore on their own without teacher supervision, it is a favorite in classrooms. Students with equal capabilities can work through this tutorial in groups of two for maximum benefits.

4. Geometry: *LOGO* (Apple, MIT, etc.) (See page 21.)
Bumble Plot (Learning Co.)
The Factory (Sunburst)
CompuRobot (CompuTech Systems)

Bumble Plot is a set of five programs building on the graphing skills introduced in *Bumble Games*, plotting number pairs to name points on a grid. These games introduce all four quadrants and therefore should follow classroom introduction of the concept of negative numbers. Children can create their own on-screen designs using number pairs. The final strategy game, "Roadblock," is excellent but is best introduced to younger classes as a group activity.

5. Statistics and Measurement: *Survey Taker* (Scholastic)
Exploring Tables & Graphs I (Xerox)
Using a Calendar (Hartley)
The Magic Cash Register (Avant Garde)

Two of the above are described in detail in "Utility Programs" (see pages 00-00). *Using a Calendar* reinforces a teacher's presentation of the measurement of time. Days, weeks, months, and years can be confusing to younger children; teachers often assume that students understand the concept of time because there is a school calendar on the wall and because students talk about important dates and holidays. Standardized tests include questions involving calendar interpretation, and this program, like Hartley's *Clock* program, carefully develops a variety of time measurement skills. Teachers can modify the program, adding or deleting data, inserting students' birthdays, school holidays, and special lo-



Exploring Tables and Graphs (Weekly Reader/Xerox)

Press any key to continue.

cal events, thus individualizing the program for their own classroom.

6. Thinking Skills: *Gertrude's Puzzles* (Learning Co.)
Incredible Lab (Sunburst)
Puzzle Tanks (Sunburst)
Gnee or Not Gnee (Sunburst)

Gnee or Not Gnee is a computerized version of games of visual discrimination of attributes found in booklets of logical thinking exercises. Given a set of Bligs and a set of shapes which are NOT Bligs, the student must discern which of a third group are Bligs. The object is to determine the rule. It is helpful to use this program as a group activity, for it gives students opportunities to verbalize their choices and to use accurate mathematics vocabulary. This program is equally effective when students work at the computer in pairs; their verbal interaction can be valuable for both students and teacher.

FOURTH – SIXTH GRADE MATHEMATICS SOFTWARE

TOPIC				
NUMBER & NUMERATION	THE KING'S RULE (Sunburst) Look for the number pattern and numbers which fit the given rule versus those which don't. Good graphics.	PROBABILITY (MECC) Simple dice-rolling experimenting, collecting data, and discovering patterns of probability.	BUILDING ESTIMATION SKILLS (Cuisenaire) Two volumes for practicing rounding, estimating percents and +, −, /, or × problems up to seven digits.	NUMBER SYSTEMS (MECC) Tutorial uses the binary system (Base 2), linking the computer to the concept of bases and place value.
WHOLE NUMBER OPERATIONS	MATH BLASTER! (Davidson) Complete tutor, drill, and game program for all four operations, fractions, and decimals. Can add own sets.	POWER DRILL (Sunburst) Reinforces the four operations in new horizontal format. Use big numbers and estimating. Tough!	TEASERS BY TOBBS (Sunburst) Six levels of difficulty. Practice the four operations in a grid or table format. Forces user to think.	PATH TACTICS (MECC) Combines strategy with basic math facts; play with a friend and choose optional levels for each player.
F R A C T I O N / DECIMAL OPERATIONS	FRACTION FACTORY (Springboard) Five games, multiple skill levels, visual – a safe, sure, useful tutorial with hints. Comprehensive.	ADVENTURES WITH FRACTIONS (MECC) Use common denominators or cross-products to order unlike fractions. RANSOM – game.	GET TO THE POINT (Sunburst) Three games reinforcing skills by computing with decimals – place value, estimation, and ordering decimals.	FRACTIONS: DECIMALS (QED) Two complete programs include tutorials and game exploration. Excellent graphics. Hands-on approach – use with fraction tiles, graph paper.
GEOMETRY	LOGO (Apple, MIT, etc.) "Turtle Geometry" involves user in actively exploring angles, distance, and geometry in meaningful ways.	PROBLEM-SOLVING STRATEGIES (MECC) Collect, organize, and analyze data to discover patterns for solving classic geometric problems.	GEOMETRY SERIES (MECC) Three tutorial disks: Understanding Points and Angles; Geometry Basics; Measuring Up.	THE FACTORY (Sunburst) Create or duplicate endless variations of geometric shape "products" while using the factory assembly line.
STATISTICS & MEASUREMENT	EXPLORER METROS (Sunburst) Novel simulation for estimating metric lengths, weights, volumes, temp. Use with measuring devices.	EXPLORING TABLES & GRAPHS II (Xerox) Top-quality introduction to understanding and creating graphs and tables. Level II for 5th-6th grades.	THE MAGIC CASH REGISTER (Avant Garde) Electronic tool for working with money and basic computing. Helps correct errors skillfully.	INTERPRETING GRAPHS (Conduit) Relating graphs to events – determining which graph is most appropriate. Interpret and use graphs to trap robbers.
THINKING SKILLS	SPINNERS AND SLUGS (Scott, Foresman) Learn specific techniques for solving nonroutine word problems involving probability.	DINOSAURS AND SQUIDS (Scott, Foresman) Strategies in problem solving with two variables. Make a table, analyze, learn techniques.	THE MARKET PLACE (MECC) Updated and improved Lemonade Stand, plus two more money-making simulations; great for group problem solving.	ARITH-MAGIC (QED) Diffy explores number differences. Tripuz examines multiplication, and Magic Squares offers techniques for solving problems in a game format.

Fourth – Sixth Grade Mathematics Software (see chart)

1. Number and Numeration:
   The King's Rule (Sunburst)
   Probability (MECC)
   Building Estimation Skills (Cuisenaire)
   Number Systems (MECC)

Building Estimation Skills is a two-disk program appropriate for any upper elementary classroom. It reinforces needed skills in rounding, "guestimating" the percent of a number, and finding the sums, differences, products, and quotients of whole numbers (two-seven digits). Depending on the number of problems chosen per exercise, a jigsaw puzzle of a monster is revealed piece by piece with each correct response. This software program also includes follow-up activities in an accompanying workbook. Teachers can follow their standard rounding lesson with added practice at the computer, one student at a time completing a particular assignment preset according to the student's individual needs, or the whole class could practice skills using this program in a laboratory setting.

2. Whole Number Operations:
   Math Blaster! (Davidson)
   Power Drill (Sunburst)
   Teasers by Tobbs (Sunburst)
   Path Tactics (MECC)

Math Blaster! is a comprehensive program with a tutorial, a practice mode, and a fast-paced game for each set of problems. Ranging from simple addition or subtraction facts through fractions, decimals, and percents, this program can be used from second through sixth grade. Teachers can insert their own sets of problems for individualized drill and reinforcement of mathematics facts. The many levels and options make it adaptable to a variety of student needs.

Teacher hint: Play the game at its slowest speed as it demands instant hand-eye coordination.

3. Fraction/Decimal Operations:
   Fraction Factory (Springboard)
   Adventures with Fractions (MECC)
   Get to the Point (Sunburst)
   Fractions: Decimals (QED)

Get to the Point includes three challenging decimal games. In "Point of Order," students fit new decimals between two randomly chosen decimals such as .35 and .4; in "Counterpoint," they search for a mystery decimal chosen by the computer. "Point in Question" is a drill and practice game which challenges students to estimate and compute with decimals using the four basic operations at selected levels of difficulty. Strategy, place value, estimating, computing, and a working understanding of decimals are all skills strengthened while playing these games. Sunburst's thoughtful teacher guide suggests ways to use this program for teacher demonstration, individual drills, or a class contest. It is lively and challenging – and far more fun than decimal worksheets.

4. Geometry:
   LOGO (Apple, Terrapin, Krell, etc.)
   Problem-Solving Strategies (MECC)
   Geometry Series (MECC)
   The Factory (Sunburst)

Problem-Solving Strategies includes four geometry-related games in which players discover patterns. "Pooling Around" simulates a pool table in which students experiment with best moves. "Thinking with Ink" is the classic four-color map problem. It randomly generates rectangular areas to be colored in such a way that no two boxes of the same color touch. "Diagonals" teaches three strategies for finding the number of diagonals in a 12-sided polygon. In "Squares," the student uses each strategy to find the number of squares on a 5×5 grid.

Teacher hints: A color monitor is needed for "Thinking with Ink." These programs are most effective as a follow-up to a chalkboard presentation. Be sure to discuss findings after students have explored each program.

5. Statistics and Measurement:
   - *Explorer Metros* (Sunburst)
   - *The Magic Cash Register* (Avant Garde)
   - *Interpreting Graphs* (Conduit)
   - *Exploring Tables & Graphs II* (Xerox/Field Pub.)

Explorer Metros is a novel simulation in which the student explores a colorful alien planet. It requires the student to make estimates that develop fluency in understanding metric units and prefixes. Problems involving grams, liters, meters, and Celsius temperatures are solved with humor. An editing feature for teachers, imaginative graphics, and novelty of format make this program outstanding. It is helpful to have concrete measuring devices handy at the computer for metric novices. Think metric!

6. Thinking Skills:
   - *Spinners and Slugs* (Scott, Foresman)
   - *Dinosaurs and Squids* (Scott, Foresman)
   - *The Market Place* (MECC)
   - *Arith-Magic* (QED)

Dinosaurs and Squids teaches a technique for solving mathematics word problems with two variables. Students can make a table, analyze the givens, experiment, discover patterns, solve a problem, and create their own problems for exploration. Both this program and *Spinners and Slugs* (probability) provide excellent enrichment for advanced students, as well as for teacher-directed class presentations.

The Market Place allows students to work in groups of two or three, or in larger teams, to compete in simulated business ventures. Who makes the biggest profit? Such factors as start-up costs, pricing, advertising, levels of production, and even the weather must be considered. *Lemonade Stand* is the most famous of these simulated business programs; there are two other money-making simulations perfect for group problem solving included.

SIXTH – EIGHTH GRADE
MATHEMATICS SOFTWARE

TOPIC				
FRACTION/ DECIMAL OPERATIONS	SURVIVAL MATH (Sunburst) Be a "Smart Shopper," run a "Hot Dog Stand," win the "Travel Agent Contest," or be a "Foreman's Assistant."	FRACTIONS: DECIMALS (QED) Two complete programs include tutorials and game exploration. Excellent graphics. Hands-on approach – use with fraction tiles, graph paper.	SUCCESS WITH MATH: FRACTIONS OR DECIMALS (CBS or Microcomputer Workshops) Each disk teaches specific topics in step-by-step solid tutorial.	RATIOS AND PROPORTIONS (JMH) Five programs introduce and reinforce ratios – writing them, solving proportions, word problems, cross-products, scale drawings.
ALGEBRA	ALGEBRA 2 (Edu-Ware) Interactive, self-paced tutorials: adding, multiplying real numbers, solving equations, problems, inequalities. Record keeping, too.	TOBBS LEARNS ALGEBRA (Sunburst) Figure out or use given formulae for completing a puzzle array. Levels of difficulty. Novel approach.	SUCCESS WITH ALGEBRA (CBS or Microcomputer Workshops) Solving equations, factoring, and solving algebraic word problems. Tutorial disks; step-by-step presentations.	GRAPHING EQUATIONS (Conduit) Four programs including two games – Green Globs (how many globs will your equation intersect) and Tracker (find graphs on a grid).
GEOMETRY	THE GEOMETRIC SUPPOSERS (Sunburst) Experiment with constructing triangles or quadrilaterals in a novel way. Needs teacher control.	PLANE FACTS ABOUT GEOMETRY (MECC) Teaches formulas, shapes, and basic geometry skills in solid tutorial format.	LOGO (Apple, MIT, etc.) "Turtle Geometry" involves user in actively exploring angles, distance, geometry in meaningful new ways.	SUPER FACTORY (Sunburst) Explore geometry in three dimensions. Create a factory that produces cubes with designs, rotate them, reproduce them. Reinforces visual skills.
MEASUREMENT	SI/METRIC TUTOR (EME) Learn a range of metric units in an interactive format using graphics; includes quizzes.	EXPLORER METROS (Sunburst) Novel simulation for estimating metric lengths, weights, volumes, and temperature. Use with measuring devices.	METRIC (JMH) Realistic applications using length, mass, capacity, and temperature. Promotes an understanding of metric prefixes by changing units by factors of ten.	BUILDING ESTIMATION SKILLS (Cuisenaire) Practice rounding, estimating percents and +, −, /, or × problems up to seven digits.
PROBABILITY & STATISTICS	SPINNERS AND SLUGS (Scott, Foresman) Learn specific techniques for solving nonroutine word problems involving probability.	INTERPRETING GRAPHS (Conduit) Relating graphs to events, choosing which type of graph is most appropriate. "Escape!" game uses graphs in a novel way.	PROBABILITY (JMH) A variety of simulations to determine outcomes or the probability of an event occurring.	WHAT'S THE SCORE? (Micro Power and Light) Assists students' understanding of the uses and reasons for statistical measures and graphs.
THINKING SKILLS	DINOSAURS AND SQUIDS (Scott, Foresman) Strategies in problem solving with two variables. Make a table, analyze, learn techniques.	PROBLEM-SOLVING STRATEGIES (MECC) Collect, organize, and analyze data to discover patterns for solving classic geometric problems.	SEMCALC (Sunburst) Trains students in a unique way to focus on the units rather than the numbers when solving word problems.	THE MATH SHOP (Scholastic) A math simulation for grades 6-8 in which students solve word problems using spreadsheets.

Sixth – Eighth Grade Mathematics Software
(see chart)

1. Fraction/Decimal Operations:
   Success with Math: Fractions or Decimals (Microcomputer Workshops)
   Survival Math (Sunburst)
   Fractions: Decimals (QED)
   Ratios and Proportions (JMH)

Survival Math is highly motivating for students and gives them practice using mathematics in practical situations. In "Travel Agent," the student organizes a trip to a distant resort and estimates the cost of the trip as close as possible to, but not exceeding, a fixed sum of money. Choices of type of transportation, meals, and hotels are offered. "Foreman's Assistant" involves users in dimensions of building material; "Smart Shopper Marathon" has students vying to make price comparisons and figuring discounts.

Teacher hint: This disk lends itself to exciting class contests.

2. Geometry:
   LOGO (Apple, Krell, Terrapin, etc.)
   The Geometric Supposers (Sunburst)
   Super Factory (Sunburst)
   Plane Facts about Geometry (MECC)

The three *Geometric Supposers* programs represent a breakthrough in making geometry come alive. The first allows students to construct points and lines, the second triangles, the third quadrilaterals, on the computer screen. Angles or lines may be measured. Students may make conjectures about angle bisectors, diagonals, or other parts of figures, and they attempt to prove or disprove them. A teacher demonstration is the best way to introduce a *Supposer* program.

3. Algebra:
   - *Tobbs Learns Algebra* (Sunburst)
   - *Graphing Equations* (Conduit)
   - *Success with Algebra* (Microcomputer Workshops)
   - *Algebra 2* (Edu-Ware)

Graphing Equations has four parts: "Equation Plotter," "Linear and Quadratic Graphs," "Tracker," and "Green Globs." Each develops students' intuition and practical skills in constructing graphs of equations. The genius of the package is typified by "Green Globs." Several points appear on a set of coordinate axes. The student tries to write the equations of lines which pass through as many of the points as possible. The more points one equation passes through, the higher the student's score.

Teacher hint: Practice with the first three parts of the program helps students achieve higher scores.

4. Measurement:
   - *SI/Metric Tutor* (EME Corporation)
   - *Explorer Metros* (Sunburst)
   - *Building Estimation Skills* (Cuisenaire)
   - *Metric* (JMH)

SI/Metric Tutor is a tutorial. It emphasizes the advantages of the metric system. Separate sections deal with each of the concepts involved: length and area, volume, mass and density, acceleration and force, very large and very small units, and temperature. A diagnostic pretest precedes each section, and a check-up follows the section. Teachers should use the appropriate section or sections of *SI/Metric Tutor* along with experimental measurement activities done in class. The graphics are excellent and the program is interactive. A forward or backward feature enables students to return to parts that need review or to skip those that do not.

5. Probability & Statistics:
   - *Interpreting Graphs* (Conduit)
   - *What's the Score?* (Micro Power and Light)
   - *Probability* (JMH)
   - *Spinners and Slugs* (Scott, Foresman)

Probability uses examples to show students how to determine the probability of simple events, and how to distinguish between independent, dependent, and mutually exclusive events. The method of calculating odds is explained. Students use the computer to simulate probability experiments with dice, coins, and other devices. Explanations are clear and understandable. The impact of the program is enhanced by using it in combination with similar classwork done with manipulative materials.

6. Thinking Skills:
   - *The Math Shop* (Scholastic)
   - *Problem-Solving Strategies* (MECC)
   - *Semcalc* (Sunburst)
   - *Dinosaurs and Squids* (Scott, Foresman)

Semcalc helps students solve word problems by focusing on the units rather than on numerical quantities alone. After using the program, students should find it easier to choose the correct arithmetic operation in word problems. They learn to recognize and reject an inappropriate answer. For example, an attempt to add the number of apples and the number of oranges yields neither apples nor oranges but "fruit."

Suppose that in a time-rate-and-distance problem, rate and distance are given and the student is asked to find the time. If the student multiplies the rate (miles per hour) by the distance (miles), the units of the product would be "miles squared per hour." The student sees that multiplying does not produce a unit of time and can try another approach.

Packages of Programs

Several software producers offer groups of programs that cover a wide range of mathematical topics. One of the best known is by Milliken Publishing Co.

Milliken Math Sequences is for grades 1-8. It provides structured drill and practice on 12 computer disks:

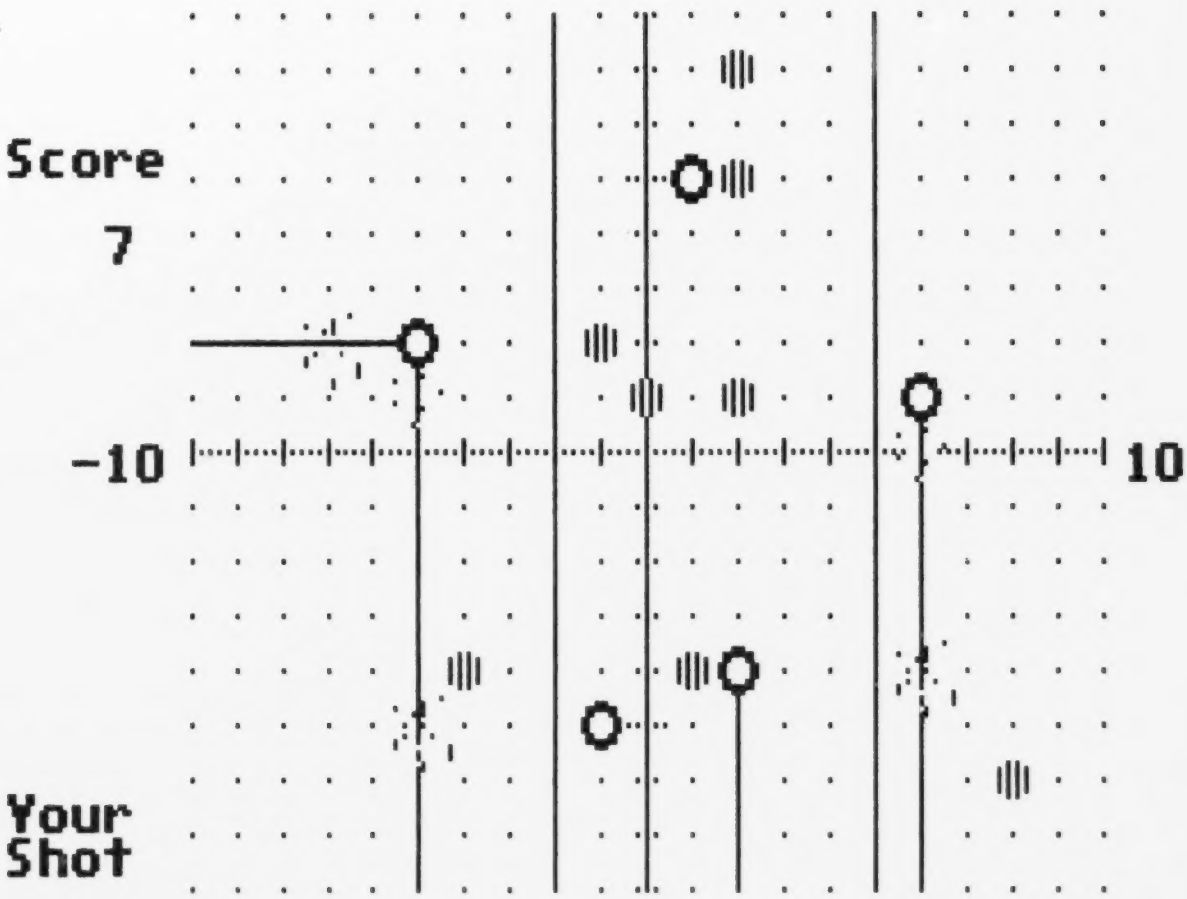
Number Readiness	Integers
Addition	Fractions
Subtraction	Decimals
Multiplication	Percents
Laws of Arithmetic	Equations
Measurement Formulas	Division

Each disk has a management feature that allows a teacher to personalize assignments for students, to review student progress, and to identify student problem areas.

Other programs spanning a wide range of grade levels and mathematical areas are:

Math Activities Courseware (Houghton Mifflin) Grades 1-8, correlates with the textbook series, "The Classroom Answer."

Number Series (SRA) Grades 2-6, number concepts, 4 disks.



> X=6

Press RETURN or ERASE for another shot.

The New Arithmetic Classroom (Sterling Swift) Grades K-8, comprehensive mathematics program including tutorials and drill and practice exercises, 14 learning packages with disks.

Micro-Math Computer Software (ETA) Grades 1-8, computation skills, 5 disks.

Mathematics Courseware Series (Scott, Foresman) Correlates with publisher's mathematics textbook series, 22 disks.

Mathematics Action Games (Scott, Foresman) Grades K-8, 6 disks.

Heath Math Worlds (D.C. Heath and Co.) Grades 4-9, emphasizes the role of mathematical thinking in scientific discovery, 4 disks.

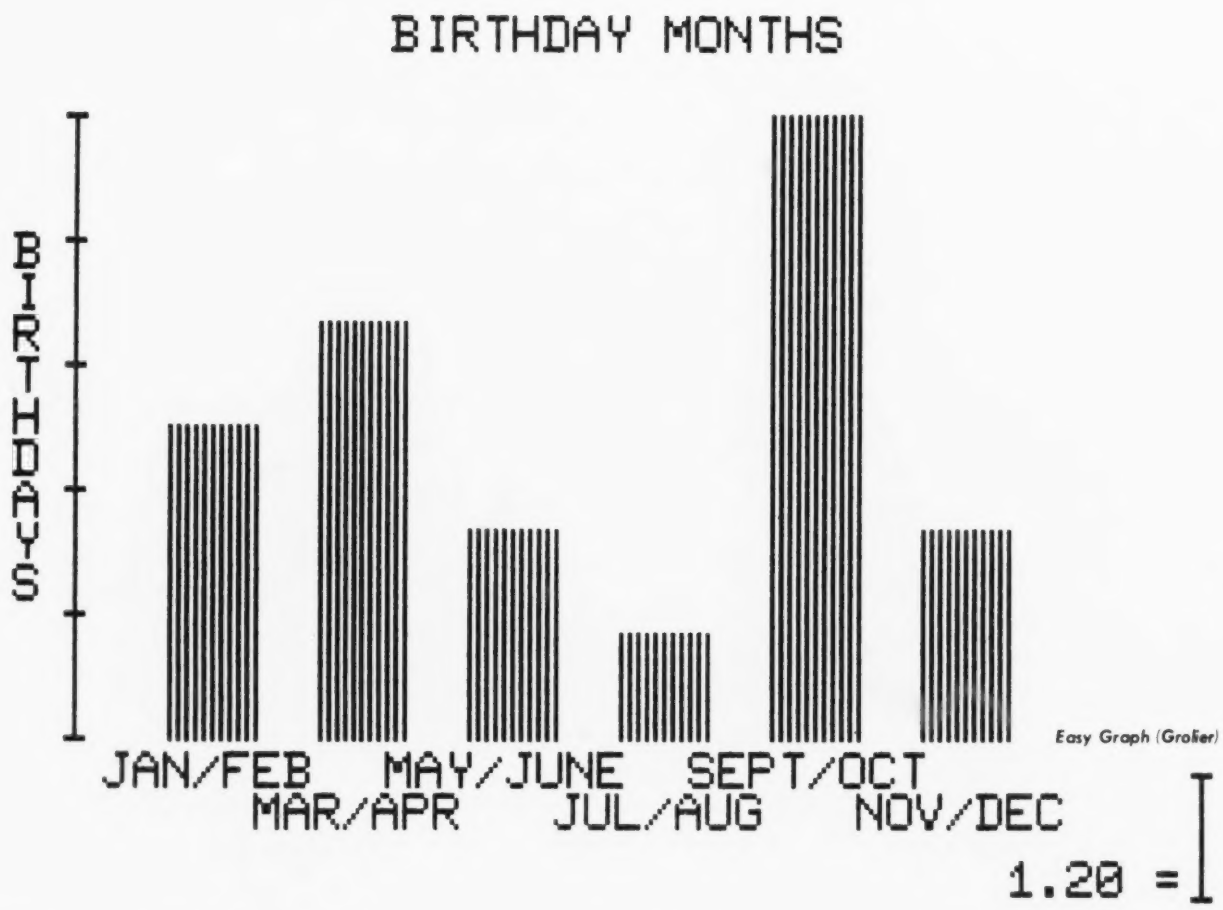
Heath Mathematics Software (D.C. Heath and Co.) Grades 1-4, goes with Heath elementary math textbooks.

Mathfinder Series (Holt, Rinehart & Winston)

Mastering Math K-4 (M.E.C.C.) Games, drills, diagnostics, ways to generate worksheets, 10 disks.

Software covering a broad range of mathematical topics (but not integrated into a management series) is published by Microcomputer Workshops, Cuisenaire, JMH Software of Minnesota, Q.E.D., and Educational Activities. Some useful examples from these series are included in the Charts on pages 17, 21, 25, and 30.

The management feature is useful when students have regularly assigned time at a computer, as for example in a computer lab. The program makes it easy for incoming students to begin where they ended the previous session. Each student can go forward at his or her own speed. Teachers can monitor work completed and modify a student's assignment if necessary. The time it takes a teacher to become familiar with the details of the management system is repaid by the convenience of using it once the mechanics are mastered.



Do you want to print this graph? Y OR N.

Utility Software

As stated in the previous section, "Software," utility programs – sometimes called "tool" programs – are growing in number, variety, and importance to mathematics teachers. The following paragraphs describe examples in each of the principal categories.

1. Programs That Make Graphs: *Easy Graph* (Grolier) *Exploring Tables and Graphs* (Xerox)

Both *Easy Graph* and *Exploring Tables and Graphs* are designed for elementary students. Each contains well-written instructions and covers both the concept of graphing and the how-to's of creating graphs using computers. The student is actively involved with the software. Of the two, *Easy Graph* is the easier for young students to use, but it is a little less flexible. In *Exploring Tables and Graphs*, Level I is for grades 3 and 4; Level II is for grades 5 and 6. It includes games in which students graph their scores. Both programs are fun to use and add new dimensions to the teaching of a topic that is valuable for showing numerical comparisons of data.

With either program, students can conduct a survey, gather data, and organize and display it in tables and graphs. They can write stories or problems which contain information that can be graphed; then they can decide which type of graph is the best for their purposes and proceed to make the graphs required.

Reading and interpreting graphs is a skill covered by standardized tests from primary grades on up; graphing programs add to the tools that can be used to teach the required skills in a context geared to students' interest and ability levels.

2. Spreadsheet Programs: *EduCalc* (Grolier)
Practicalc II (Practicorp)

Although almost any adult spreadsheet program can be used with students, *EduCalc* was written for elementary and junior high school students. The program is on two sides of a disk, with a built-in instructional sequence that is broken into short segments. A special "template" makes it easy to set up tables of school-related data. It is truly "user-friendly."

Teachers with no previous experience with a spreadsheet will quickly be at home with *EduCalc*. The manual identifies many curriculum-based applications. Spreadsheets work in rows and columns and therefore are valuable for organizing various types of information. Data may be either numerical or alphabetical. Classes of vertebrates and Presidents of the United States are among the large variety of listings that have been put on spreadsheets.

Columns can be added, averaged, or sorted rapidly. Entire tables can be printed out. A favorite feature of a spreadsheet program is its ability to handle numerical corrections.

Let us suppose that one corrected figure is entered in place of one incorrect figure, that the columns are totaled horizontally across and the rows vertically down the spreadsheet. All the subtotals, totals, and grand totals that include the new figure are automatically and immediately corrected to reflect the new value.

Spreadsheet programs encourage students to ask "what if?" questions. For example, students can enter new, higher values for revenue or a lower figure for expenses and see the result. It is equally simple to change back to the original figure when, and if, necessary.

A given spreadsheet entry, or a series of entries, can be programmed to apply a formula that uses other data entries. For example, with rates in one column and corresponding times in another, a spreadsheet can easily be set up to compute distances. Areas, perimeters, volumes – virtually any problem solved by a formula – can be handled similarly.

More and more interesting classroom applications are being reported. "Spreadsheets in the Classroom" (*Creative Computing*, October 1985) describes how simultaneous equations may be solved. The analysis of living conditions in "Social Studies, Spreadsheets, and the Quality of Life" (*The Computing Teacher*, December-January1985-1986) relies heavily on mathematics. The January 1986 issue of *Teaching and Computers* contains a variety of suggestions for using spreadsheets.

```
 ENTER              FILES       CHANGE                ^
                    FORMAT                            :
-------------------------------------------------<-  ->
A1  :                                                 :
          A              B             C              V
1                     STUDENT  ORGANIZATION
2
3
4  EXPENSES              SEP         OCT         NOV
5
6  SCHOOL PAPER
7    printer             65.45
8    photography         53.34
9  DANCES/PROMS
10 music                  0.00
11 hall rental            0.00
12DRAMA CLUB
13 props/supplies       101.75
14 ticket/program        32.12
15SCHOOL STORE
16 sweatshirts          550.55
-------------------------------------------------------
   SPACE BAR to change command;    RETURN
   to start, add to, or edit spreadsheet
```

Edu Calc (Grolier)

3. Data Base Software: *Friendly Filer* (Grolier)
Bank Street Filer (Scholastic)
PFS: File (PFS)

Each of the three named data base programs has been used successfully in elementary school classrooms. All include well-written manuals and both *Friendly Filer* and *Bank Street Filer* include built-in tutorials. *Friendly Filer* is the easiest to learn but the least flexible.

A data base program allows the student to design a form to be used for entering information of a certain kind, e.g., books read, records in a collection, or types of geometric shapes. Information is then entered into the computer, where it becomes the data base. Thereafter, the data base can be searched and particular information can be extracted, displayed on the screen, and printed.

Data bases often relate to mathematics as well as science, history, or geography, and thus they develop interaction between disciplines.

It's important for teachers to spend a little time becoming familiar with the modus operandi of a given program before introducing it to students. It also takes time to create a data base, especially one with 50 or more entries. However, the result can be extremely worthwhile. One data base, say on dinosaurs, can be referred to year after year and added to as new information comes to light.

4. Special Purpose Programs: *The Magic Cash Register* (Avant Garde)
Square Pairs (Scholastic)
Crossword Magic (Mindscape)
Tic Tac Show (Advanced Ideas)

The Magic Cash Register turns the computer into a colorful and very active cash register. The student enters names of items, the number of each, and the cost of each. If the student chooses the "Use Your Brain" option, he or she can perform all the required mathematics operations to determine total cost and change from a given sum tendered in payment.

The program is an example of "Artificial Intelligence," as it almost instantly analyzes the student's mathematics, pinpoints errors, and suggests ways to make corrections. Second through sixth grade students find the program ideal for running a class store, developing money skills and basic computation skills.

Square Pairs is an electronic version of "Concentration." Visual memory is strengthened as two pieces of information are matched. The difficulty of the game can be set at any desired level. Any paired information (e.g., addends-sums, factors-products) may easily be built in.

Crossword Magic offers an attractive method of focusing on a particular set of vocabulary words, either in mathematics or in other subject areas. It's easy to learn, easy to use, and highly motivating. Teachers can create their own crossword puzzles in short order, or better yet, have students create them.

Tic Tac Show replicates the TV program, "Tic Tac Dough." It is for two persons or teams. The quiz format and ample space to insert problems make it easy to adapt *Tic Tac Show* to a wide variety of ages and topics. Problems may be of multiple choice, true-false, fill-in, or completion format. Sample problems come with the program; teachers can save their own program ideas on disk.

5. Multiple Utilities: *Apple Works* (Apple Computer)

In the world of business, software producers are finding a huge market for programs that combine spreadsheet, data base, and word processing capability on one or two disks. It is very likely that, as prices come down, the educational market for such programs will expand.

Multiple utility programs make it possible for a letter or document to incorporate figures coming from a spreadsheet or from a data base. A student might write a social studies paper with the word processing component of *Apple Works* and include population figures taken from its data storage with statistical help from the program's spreadsheet section.

Games

Differences of opinion exist as to the value of computer games in the teaching of mathematics.

One opinion is that computer games develop little but eye-hand coordination, distract students from other, better programs, and cause students to be excessively concerned with shooting.

The contrary view is that games develop logical thinking, are highly motivating to students, improve concentration, and can play a valuable role in mathematics learning. Many games stress reading for content, organizing data, and group participation.

Both views can be correct depending on the particular games being considered. A safe rule for teachers to follow is to allow students to use computer games only after teachers have personally seen and approved them.

Some games are computer adaptations of long familiar classroom favorites. Three examples are:

Guess My Number
Pico Centro (also called Bagels)
Hangmath

These can be obtained from M.E.C.C.or other suppliers of public domain software. (See Appendix A.)

The built-in game format of many drill and practice programs appears to improve appeal of the program to students and, correspondingly, the effectiveness of the program. Examples are:

Math Blaster! (Davidson)
Academic Skill Builder in Math (DLM)
Adventure Alpha (Milliken)
Bumble Games (Learning Company)

When programs such as these are used with selected students, the students often make appreciable gains in both speed and retention of math fundamentals. Best results come from short periods of use on successive days.

Many classic board games are available on disk. The amount of strategy, thinking ahead, and checking of combinations is essentially the same for the computerized version as for the traditional versions; nevertheless, students appear to derive an extra thrill from competing with, and occasionally beating, the computer. Games in this category include chess, checkers, backgammon, Mastermind, and Othello.

Worksheet and Test Generators

The microcomputer's ability to generate worksheets can save time for mathematics teachers and provide substantial assistance to teachers. Several computer programs are available which enable teachers to run off review sheets or tests for each class or for a subset of each class. A different but equivalent worksheet for every student is feasible.

Test generators enable teachers to create four different test formats – multiple choice, true-false, matching, or completion questions. The number of problems per page, the difficulty range, and the print size are often within the control of the teacher.

Five worksheet generator programs are:

Mathematics Worksheet Generator (Heath-Sterling Swift)
The EA Mathematics Worksheet Generator (Educational Activities)
Mathsheet (Houghton Mifflin)
Study Guide (MECC)
Mastering Math Worksheet Generator (MECC)

LOGO

LOGO's turtle graphics and other features are effective means of developing spatial organization, left-right orientation, measurement, differentiating polygons, understanding angles and degrees, estimating distances and angles, cause and effect relationships, logical thinking, and problem solving.

LOGO can be used to teach children an important concept in the learning of mathematics which is often neglected. That is, there are many different ways to approach and solve a problem. LOGO moves a child beyond the concrete manipulation of objects to the next level of abstraction. LOGO enables students to explore the two-dimensional world of plane geometry, a process which can serve as preparation for a more formal study of geometry.

LOGO can be taught in a computer lab as a separate topic, but it is even more effective when it actively reinforces mathematics concepts taught in the classroom. Using LOGO as a math tool, classroom teachers can introduce how-to's and basic vocabulary to the whole class, yet allow individual "guided exploration." Such a practice is recommended for maximum mathematical benefits. Teachers should structure each lesson with particular goals in mind and reinforce them with follow-up activities.

Noncomputer Pre-LOGO Introduction

There are many pre-LOGO and offscreen activities that can introduce basic LOGO concepts in ways meaningful to students in kindergarten and first grade. Examples of ways to introduce concepts such as spatial awareness, directionality, position in space, visual discrimination of geometric shapes, understanding symmetry and measurement, using concept words dealing with comparisons follow:

1. Whole body activities such as Simon Says, moving FORWARD and BACK, *acting out the turtle's responding to basic LOGO commands.* Simon can also command players to TURN RIGHT or TURN LEFT.
2. Baseball diamonds, maps, and mazes made with masking tape create walking worlds on the classroom floor for students. Partners take turns giving LOGO commands or being the turtle and obeying.
3. Stuffed turtles named LOGO, or plastic turtles in a sand tray, can make moves in LOGO lingo: BACK 10, RIGHT 90.
4. Turtle magnets on a magnetic board representing a LOGO screen can reorient students from the horizontal to the vertical plane.
5. Freestanding robots such as BIG TRAK or CompuRobot, with the left and right sides marked clearly, can be programmed to move along a number line or "track." Start with FORWARD and BACK commands, then introduce turns (which are not in 360 degree units, but match clock minutes). Children are highly motivated to listen and follow a teacher's set of oral directions, itself an important skill at this level. "Make the robot go down the track and stop at the three small red triangles."
6. Floor covering marked in a 6" square grid pattern (linoleum, rug sample, etc.) for structuring "Be LOGO the Turtle" games.
7. Folding ruler to demonstrate each of the polygons, from triangles to octagons.
8. Introduce geometric shapes with large cutouts to trace. Each child describes and verbalizes movements using LOGO lingo.

Hint: Always use the correct LOGO vocabulary, such as FORWARD and BACK rather than UP and DOWN. Have each student verbalize his or her actions, even learn to take simple notes when planning programs on or off the computer.

Onscreen Pre-LOGO

Four-year-olds can begin exploring the turtle world on the computer using single-key commands such as those used in *KinderLogo*, *Delta Drawing*, or *EZ-LOGO*. Such programs work well with children under eight who have not yet grasped the meaning of 2-digit numbers and aren't ready for the notion of 360 degrees. Another useful option is "Turtle Tot," a floor robot connected to a computer with a long cord and controlled from the keyboard. An effective bridge between independent robots and two-dimensional computer monitors, "Turtle Tot" can also speak and can be programmed with single-key instant LOGO commands.

Teacher tips:

1. Have a big poster handy with the key commands and pictorial clues to indicate the result of pressing each letter. Keyboard templates are also helpful, with the commands close to the keys.
2. Use acetate sheets on the computer screen, with mazes, initials, or shapes to trace, or colored stickers as onscreen goals.
3. Let children work in pairs. Watch each student and discover learning styles and other useful diagnostic information. How does each student tackle a problem?

Using the LOGO Language

Many of the above tips and techniques work equally well when using the LOGO language itself. There are many books devoted to the specifics of teaching with LOGO; a few suggestions follow:

1. Writing procedures and editing them is challenging. A few second graders and more third graders are ready for this challenge, but many should wait until fourth-fifth grades. Teachers can set up a series of LOGO commands: RT ; BG ; FD ; PC ; LT ; BK ; END. Each student fills in his or her own inputs, and writes a procedure TO JOHNNY, and compares the varied results.

2. Circles: body activities are a must in preparation for LOGO circle-making. It is also the time to introduce the REPEAT command.

3. Create a classroom set of LOGO cards: each student draws a picture on the front of an index card and writes the procedure on the back; then the cards are ready for classmates to explore and extend.

4. Use graph paper or dot matrix dittos (see sample) for creating student worksheets as well as for students' own planning of LOGO projects.

5. Variables, recursions, and geometric coordinates are high-level concepts and need understanding on the part of the teacher.

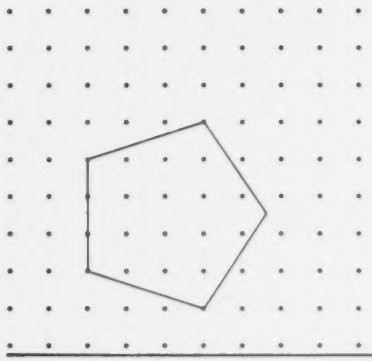
6. Teach accurate mathematical ideas in advance of computer activities: what are a regular polygon, an external angle, number lines, and negative numbers? Make the connection between mathematics and the LOGO world.

Hint: Printing out students' designs should be a top priority. If you don't use *Delta Drawing*, there are screen dump programs as quick and easy, such as *PRINT-IT!* (Texprint). Such capabilities enhance LOGO's appeal.

There are other ways to extend LOGO. The color capabilities of *Delta Drawing* can be used to color LOGO designs. A joystick or Koala Pad can be used instead of the keyboard. There is a Voice Input Module allowing voice control of the software. Sprite LOGO is an exciting version which adds multiple turtles that can move on the screen at varying speeds.

Sample worksheets from Reinhold Wappler's *LOGO and Mathematics Workbook* follow as guides to help teachers connect LOGO with mathematics instruction.

REGULAR CLOSED SHAPES (REVIEW)



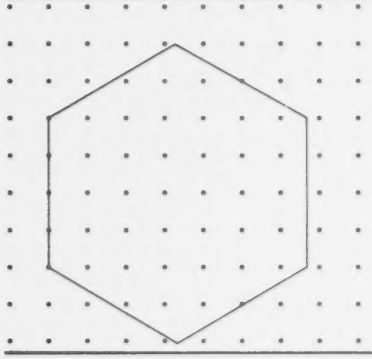
1 Name of Shape _____

Number of Sides _____

Size of Each Turn _____

Write the Repeat Command to Draw the Shape

Repeat ____ [FD _____ RT _____]



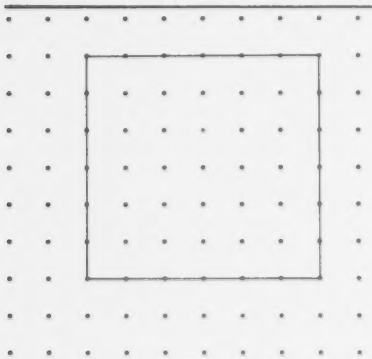
2 Name _____

Number of Sides _____

Size of Turn _____

Write the Repeat Command to Draw the Shape

Repeat ____ [FD _____ RT _____]



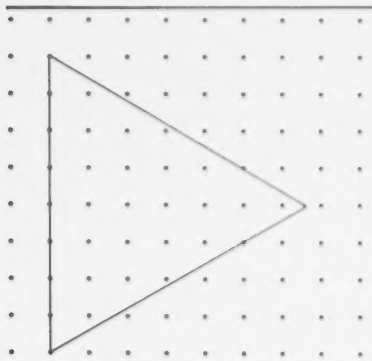
3 Name _____

Number of Sides _____

Size of Turn _____

Write the Repeat Command to Draw the Shape

Repeat ____ [FD _____ RT _____]



4 Name _____

Number of Sides _____

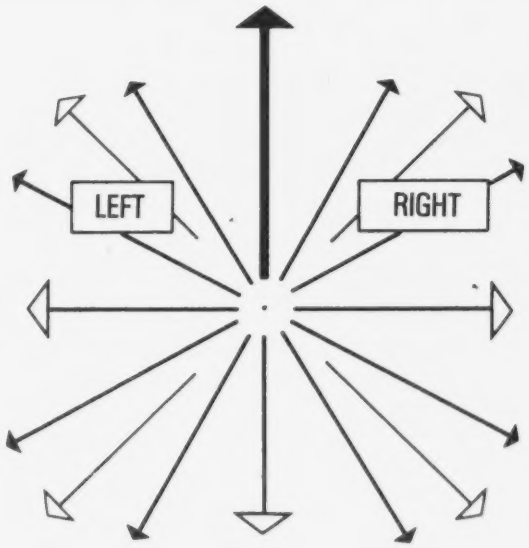
Size of Turn _____

Write the Repeat Command to Draw the Shape

Repeat ____ [FD _____ RT _____]

TURN INDICATOR

Copy onto transparent acetate and cut apart.
Hold it against monitor with center over the turtle's drawing point.
Align main arrow with turtle's direction.
Read off the input to the LEFT or RIGHT turn command.

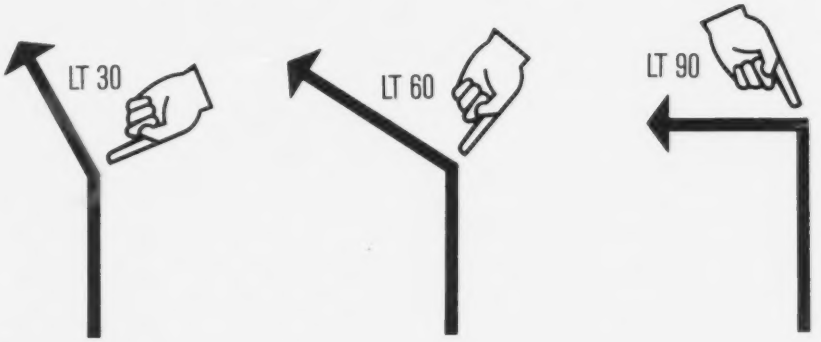


DOT MATRIX DITTO

Make copies for students to use for creating drawings.
Matches size of Apple's LOGO turtle world.

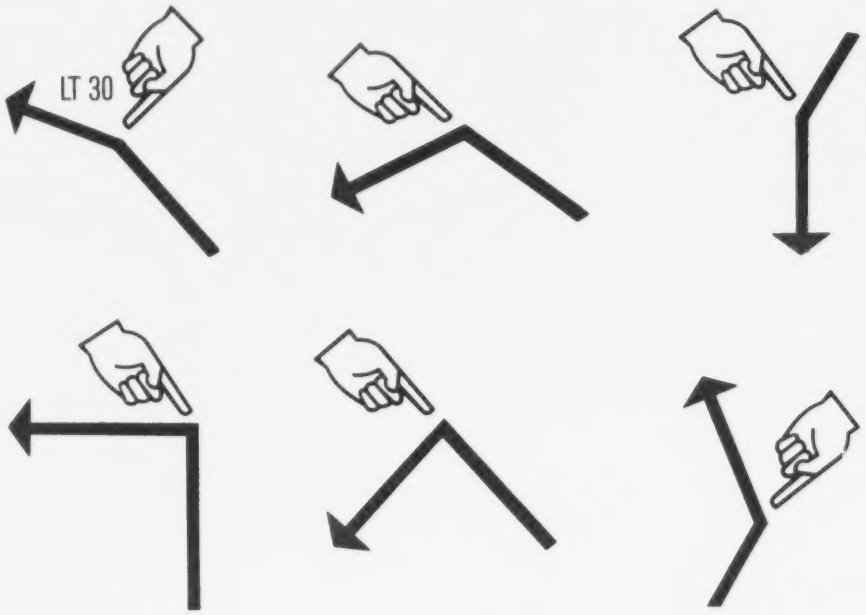
LEARN TURNS

Look at these Left Turns:



Now Match them with the Left Turns Below, and Write the Logo Command for Each One.

First One is Done as an Example.



LOGO
AT
WORK

LOGO Resources

There are many books, sets of task cards, work texts, and other supplementary materials for teachers wanting to make the most of LOGO. Many resourceful teachers have compiled their own list of favorites. Sources include:

"Selected Books and Materials for Learning with LOGO." K-12 Micro Media Inc., 172 Broadway, Dept. L, Woodcliff, NJ 07675.

Learning with LOGO, by Daniel Watt. McGraw-Hill, New York, NY 10017. A "must" in any school's LOGO collection. Has an accompanying Procedures Disk. MIT or Apple LOGO versions.

LOGO Newsletter. The National LOGO Exchange, P.O. Box 5341, Charlottesville, VA 22905. Filled with tips and how-to's.

The Turtle's Sourcebook, by Beardon, Martin & Muller. Young People's LOGO Association (YPLA), 1208 Hillside Drive, Richardson, TX 75085.

My Children Use Computers, by Beverly Hunter. Reston Publishing Company, Reston, VA 07630. Includes specific lesson plans for using LOGO, organized by grade level. Specific activities appropriate for third-fourth graders are listed, followed by another set for fifth-sixth graders.

Monroe 2-Orleans BOCES, Spencerport, NY 14559, (716) 353-2424. A series of LOGO "chapters" of extremely thoughtful and useful ideas.

LOGO and Mathematics Workbooks, by Reinhold Wappler, 252 Canten Street, New Canaan, CT 06840. Offers a structured approach with helpful off-computer activities.

Teaching and Computers, 730 Broadway, New York, NY 10003. Each issue has classroom LOGO ideas, posters, and/or activity cards.

Educational Services, LOGO Computer Systems, Inc. (LCSI), 555 West 57th Street, Suite 1236, New York, NY 10019, (212) 765-4780. Useful source for workshops and information about Sprite LOGO.

Mindstorms: Children, Computers and Powerful Ideas, by Seymour Papert, Basic Books, New York, NY 10016.

BASIC

Knowing how to program in BASIC is not a prerequisite for the great majority of those who teach mathematics. It is equally true, however, that a knowledge of BASIC is an asset to any mathematics teacher. Likewise, although there is a place for programming in the curriculum, not everyone in our society needs to be able to program a computer. The extent and scope of programming skills, what language to use, and when it shall be taught will partially be determined by a review of the needs of each school's student population.

Many fundamental concepts are common to both junior high mathematics and to computer programming. For example, using "For-Next Loops," a cornerstone of BASIC, improves students' understanding of the all-important concept of variables. Similarly, learning to write programs that generate graphics often results in students' becoming more at home with coordinate systems.

The following is a list of some of the many mathematical ideas that can be programmed by first-year programmers:

The average of a group of numbers
Greatest common factor
Least common multiple
Primes from 1 to N
Prime factors of a number
Powers of a series of integers
Fibonacci numbers
Interest computations
Solution of linear equations
Solution of simultaneous equations
Flipping a coin or spinning a spinner N times

Some computer educators believe that the teaching of BASIC should be discontinued and a more "structured" language like PASCAL taught instead. Those who argue for an end to BASIC allege that too many programs written by students are unduly complicated and therefore difficult, if not impossible, for others to understand.

The criticism more properly applies to the way the language may have been taught than to BASIC itself. Well-designed, easy-to-follow programs can readily be written in BASIC if students are taught the essentials of good programming.

It is particularly advantageous for those who are gifted at mathematics and those with a real interest in computing to start learning BASIC during their junior high years. Besides increasing their understanding of mathematics, students can:

Develop logical thinking skills
Refine problem-solving skills
Acquire a marketable skill
Appreciate the computer as an intellectual tool

BASIC programming is often a separate course offering. The syllabus may follow an existing textbook or it may be one prepared by the instructor. The primary consideration is that the course stress structured programming. A structured program has a group of "modules" and a mechanism for integrating the modules into the whole. Each module performs one sub-function of the complete program.

In the absence of a separate BASIC programming course, many mathematics teachers in grades 6-8 incorporate units on programming into their mathematics classes. Where BASIC programming cannot easily fit into a school's schedule, an alternative is to organize groups that meet during club or activity time.

The New York State seventh and eighth grade mathematics curriculum, currently being prepared by the Bureaus of Mathematics Education and Curriculum Development of the State Education Department, has an optional section on computer programming at both grade levels.

A list of materials appropriate for classroom use will be found on the next page. Interesting, short programs in computer magazines can often be useful for class presentations.

Computer Worksheets, by Snover and Spikell (D.C. Heath & Co.,1983), was written as an adjunct to the Heath Mathematics Series, but it correlates with most junior high mathematics curricula. There are four levels, 5-8.

Programs in *Computer Worksheets* are written in a form of BASIC that is acceptable on the majority of computers found in schools. The following program from Level 6 provides practice in estimating with decimal quantities:

```
 10 A = 3.0
 20 B = 1.0
 30 PRINT "WHAT TOTAL VALUE;"
 40 INPUT C
 50 PRINT
 60 PRINT A; "X NUMBER + ;"
 70 PRINT B; " = "; C
 80 PRINT "WHAT IS YOUR GUESS FOR THE
        NUMBER;"
 90 INPUT N
100 PRINT
110 D = A * N + B
120 PRINT A; " X "; N ;" + ";
130 PRINT B; " = "; D
140 IF ABS (C-D) 0.0001 THEN 180
150 PRINT "THE TOTAL VALUE IS NOT"; C
160 PRINT "TRY AGAIN"
```

170 GO TO 50
180 PRINT "YOUR CHOICE IS CORRECT"

Along with each program, the Heath series gives the teacher suggestions on how to use it. Students also are given suggestions on how to modify and build on each program. All programs can be easily reproduced.

****

Materials That Help Teach BASIC

Computer Software
Hands-on BASIC Programming (Edu-Ware)
Let's Explore BASIC (Media Materials)
The New Step by Step (PDI)
Discover BASIC (Sterling Swift)
Some Basic BASIC (Educational Activities)
Blazing the BASIC Trail (Sunburst)
FOR Your NEXT Adventure (Sunburst)
Boxes of Activity Cards
Beginning BASIC (Sunburst)
Intermediate BASIC (Sunburst)
Books
Problem Solving with BASIC, Walter J.Koetke, Scholastic, New York, 1986
Computer Literacy: A Hands-on Approach, Luehrmann & Peckham, McGraw-Hill, New York, 1984

CONCLUDING REMARKS

This guide presents a broad overview of ways to combine computers and the teaching of mathematics from kindergarten through eighth grade. The software programs mentioned in this document can be run on one or more of the computers commonly found in elementary schools.

The amount of mathematics software for the K-8 grade span is so great that it is impossible to review it all. The fact that a particular program is not listed should not be considered an adverse judgment of it.

A major goal has been to give teachers criteria for choosing appropriate software and a method for organizing the software they have, i.e., by mathematics topic and by grade level. An effective selection and organization process is particularly important because new software is continuously appearing. Today's chart may need to be updated next week and revised next month!

The computer can easily become a natural part of one's teaching repertory, fitting into any mathematics curriculum. Using five good programs in five different math areas is better than having twice as many programs limited to only one or two mathematics topics.

Our goal has been to make mathematics teaching and computer use more interrelated, more rewarding, more interesting, and more fun.

APPENDIX A
SOFTWARE SUPPLIERS

The following are companies providing software particularly useful for the teaching of mathematics; samples of their products are mentioned in this handbook.

ADDISON-WESLEY	2725 Sand Hill Rd., Menlo Park, CA 94025
APPLE COMPUTER	20525 Mariani Ave., Cupertino, CA 95014
AVANT GARDE	Box 30160, Eugene, OR 97403
BRODERBUND	Box 12947, San Rafael, CA 94913
CONDUIT	Box 388, Iowa City, IA 52244
CUISENAIRE	12 Church St., Box D, New Rochelle, NY 10805
DAVIDSON & ASSOCIATES	3135 Kashiwa St., Torrance, CA 90505
D.C. HEATH & CO.	125 Spring St., Lexington, MA 02173
DIDATECH	549-810 W. Broadway, Vancouver, BC V5Z4C9
DLM	One DLM Park, Allen, TX 75002
EME	Box 17, Pelham, NY 10803
GROLIER	Sherman Turnpike, Danbury, CT 06816
HARTLEY	Box 431, Dimondale, MI 48821
HARVARD ASSOCIATES	260 Beacon St., Somerville, MA 02143
HOLT	383 Madison Ave., New York, NY 10017
HOUGHTON MIFFLIN	Box 683, Hanover, NH 03755
JMH SOFTWARE	Box 41308, Minneapolis, MN 55441
KRELL	1320 Stony Brook Rd., Stony Brook, NY 11790
LEARNING CO.	4370 Alpine Rd., Portola Valley, CA 94025
MCEP	Lawrence Hall of Science, University of California, Berkeley, CA 94720
MECC	3490 Lexington Ave. N., St. Paul, MN 55112
MICROCOMPUTER WORKSHOPS	225 Westchester Ave., Portchester, NY 10573
MILLIKEN	1100 Research Blvd., St.Louis, MO 63132
MINDSCAPE, INC.	3444 Dundee Rd., Northbrook, IL 60062
QED	2924 N.E. Stanton, Portland, OR 97212
RANDOM HOUSE	201 W. 50th St., New York, NY 10022
SCHOLASTIC, INC.	730 Broadway, New York, NY 10003
SCOTT, FORESMAN	1900 East Lake Ave., Glenview, IL 60025
SPINNAKER	1 Kendall Square, Cambridge, MA 02139
SPRINGBOARD	7807 Creekridge Circle, Minneapolis, MN 55435
STERLING SWIFT	7901 South IH – 35, Austin, TX 78744
SUNBURST	39 Washington Ave., Pleasantville, NY 10570
XEROX/FIELD PUB.	245 Long Hill Rd., Middletown, CT 06457

NONPROFIT ORGANIZATIONS

The following organizations supply public-domain software. Contact each for the latest catalog and method of purchase.

APPLE AVOCATION ALLIANCE (3A)	1803 Warren Ave. Cheyenne, WY 82001

BAROQUE PRODUCTIONS	1124 Brady Ave. Modesto, CA 95350
CUE (Computer-Using Educators)	1775 Educational Park Dr. San Jose, CA 95113
ROBBINSDALE AREA SCHOOLS	4148 Winnetka Ave., N. Minneapolis, MN 55427
SOFTSWAP	San Mateo County Office of Education 333 Main St. Redwood City, CA 94063

APPENDIX B
COMPUTER MAGAZINES OF INTEREST TO TEACHERS

Arithmetic Teacher. National Council of Teachers of Mathematics (N.C.T.M.), Reston, VA 22090

Catalyst. Western Center for Microcomputers in Special Education, 1259 El Camino Road, Suite 275, Menlo Park, CA 94025

Classroom Computer Learning. Pitman Learning, Inc., Cicero, IL 60650

Classroom Computer News. International Educations, Inc., Watertown, MA 02172

Closing the Gap. P.O. Box 68, Henderson, MN 56044

Creative Computing. P.O. Box 789-M, Morristown, NJ 07960

The Computing Teacher. University of Oregon, Eugene, OR 97403

Electronic Learning. Scholastic, Inc., Englewood Cliffs, NJ 07632

Journal of Computers in Mathematics and Science Teaching. Association of Computers in Mathematics and Science Teaching, Austin, TX 78710

Mathematics Teacher. N.C.T.M., Reston, VA 22090

Teaching and Computers. Scholastic, Inc., Englewood Cliffs, NJ 07632

APPENDIX C
SOFTWARE DIRECTORIES

A) COMPREHENSIVE CATALOGS

ACADEMIC SOFTWARE
1415 Queen Anne Rd.
Teaneck, NJ 07666

BECKLEY-CARDY
114 Gaither Dr.
Mt. Laurel, NJ 08054
Computer Education

RADIO SHACK EDUCATIONAL DIV
1400 One Tandy Center
Fort Worth, TX 76102
TRS-80 Educational Software Directory

B) SOFTWARE REVIEWS

EDUCATIONAL INSIGHTS
150 W. Carob St.
Compton, CA 90220
Courseware Report Card

SCHOOL AND HOME COURSEWARE, INC.
301 Mesa
Fresno, CA 93714
Digest of Software Reviews: Education

EPIE INSTITUTE
Teachers College
Columbia University
Box 27
New York, NY 10027
PRO/FILES

CENTER FOR LEARNING TECHNOLOGIES
New York State Education Department
Albany, NY 12230
Guide to Software Selection Resources:
Part Four – Science & Mathematics

THE APPLE EDUCATION FOUNDATION
20525 Mariani Ave.
Cupertino, CA 95014
Journal of Courseware Review

NORTHWEST REGIONAL EDUCATIONAL LABORATORY
300 S.W. 6th Ave.
Portland, OR 97204
Microshift

LINC ASSOCIATES
46 Arden Rd.
Columbus, OH 43214
The Specialist Directory: A Guide to Software Sources for Special Education

TRACE RESEARCH AND DEVELOPMENT CENTER ON THE COMMUNICATION CONTROL AND COMPUTER ACCESS FOR HANDICAPPED INDIVIDUALS
314 Waisman Center
1500 Highland Ave.
Madison, WI 53706
Trace Software/Hardware Registry

C) SOFTWARE REVIEWS AND JOURNALS

Up-to-date reviews can be found in every issue of educational computer magazines and journals. (See Appendix B.) These periodicals frequently give helpful tips on specific ways to use programs in the classroom, with personal anecdotes by teachers who have used the software

APPENDIX D
COMPUTER COORDINATOR JOB DESCRIPTION

The computer coordinator is responsible for:

1) Assisting administrators and teachers in curriculum planning and development that reflects
   - the integration of technology in all subject areas as a tool for instruction
   - student needs related to learning about computers, and
   - student needs related to learning computer programming
2) Long-term program and fiscal planning
3) Teacher and administrator education (i.e., in-service, coaching, facilitator)
4) Software and hardware selection, acquisition, and maintenance
5) Monitoring and evaluating programs

The computer coordinator acts as a resource person for teachers, administrators, school board members, parents, and other members of the community. This person is responsible for coordinating the use of the computer laboratory by teachers and students and for teaching computer.

This person works with classroom teachers so that there is an understanding of the curriculum goals and the ways computers will be used in reaching the goals. The computer coordinator works with classroom teachers to schedule the use of computers and to assist students as they work with computers.

Competency areas for the computer coordinator:

1) Technical knowledge of computer science, computer education, and appropriate methods of integrating technology in all curriculum areas
2) Knowledge of appropriate human, print, and nonprint resources to assist school staff in achieving curriculum goals
3) Ability to plan and implement in-service training

APPENDIX E
STUDENTS WITH HANDICAPPING CONDITIONS

The Board of Regents, in revising the Part 100 Regulations of the Commissioner, has made a strong commitment to integrating the education of students with handicapping conditions into the total school program. According to Section 100.2(s), "Each student with a handicapping condition, as such term is defined in Section 200.1(ii) of this Chapter, shall have access to the full range of programs and services set forth in this Part to the extent that such programs and services are appropriate to such student's special educational needs." Districts must have policies and procedures in place to make sure that students with handicapping conditions have equal opportunities to access diploma credits, courses, and requirements.

The majority of students with disabilities have the potential to master the curricula content requirements for a high school diploma. Most students who require special education attend regular education classes in conjunction with specialized instruction and/or related services. These students must attain the same academic standards as their nonhandicapped peers in order to meet these requirements. For this reason, it is very important that at all grade levels students with handicapping conditions receive instruction in the same content areas so as to receive the same informational base that will be required for proficiency on statewide testing programs and diploma requirements.

It is as important that teachers providing instruction through this syllabus/curriculum be familiar with how the process of special education is implemented. This appendix will provide clarification as to how students with handicapping conditions participate in both regular and special education programs. The coordination and integration of both of these programs are essential for the benefit of all students.

Providing Special Education

A student who is suspected of having a handicapping condition which adversely affects the student's educational performance must be referred to the Committee on the Handicapped (COH) by either the student's parent, a professional staff member of the school, a physician, a judicial officer, the commissioner or designee of a public agency with responsibility for welfare, health, or education of children, or the student, on his or her own behalf, if he or she is 18 years of age or an emancipated minor. The referral must be in writing.

The COH then must proceed to conduct an individual evaluation. This evaluation is a comprehensive assessment which is used by the COH to determine whether the student has a handicapping condition which adversely affects the student's educational performance. If the Committee on the Handicapped determines that the student is eligible for special education, the COH and the student's parents develop an individualized education program (IEP). This recommendation must include:

- present levels of performance and individual needs according to the four criteria areas of academic, social, and physical development, and management needs,
- classification of the handicapping condition,
- annual goals,
- recommended program, class size, extent of participation in regular education,
- projected date for initiation of special education, amount of time per day, and projected review date,

- specialized equipment and adaptive devices,
- testing modifications, and
- recommended placement.

Following the COH recommendation, the Board of Education has 30 school days to arrange for implementation. After the student enters the program, a planning conference is held to complete the development of the individualized education program by adding short-term objectives and objective criteria thereof and evaluation procedures for determining whether the instructional objectives are being met. The student's program is reviewed at least annually and the student receives a comprehensive reevaluation at least every three years.

The entire process has corresponding time lines and due process for each step.

As the Committee on the Handicapped makes its recommendation for appropriate programs and placements, careful consideration is given to the concept of the least restrictive environment. The concept of least restrictive environment has three key components:

- Special education needed by the student – This means that the recommended program of a handicapped student must meet his or her individual needs. This ensures that any placement into either special or regular education programs must be appropriate. If a student is recommended for participation in a regular education setting, then the student should have abilities which would allow that student to benefit from such instruction.
- Participation with nonhandicapped peers to the maximum extent appropriate – Consideration of this component ensures the integration of handicapped students with their nonhandicapped peers, whenever appropriate to their individual needs.
- Proximity to the student's place of residence – Consideration of this component maximizes the potential interaction between parents and school, as well as the student's interaction with other students in the home school area.

The concept of least restrictive environment is important for all educators to understand. Its intent is to include handicapped students in the total educational system whenever possible, but it also ensures that such placements be appropriate. Therefore, any placements that would seem to be inappropriate should constitute a referral to the COH for consideration.

The teacher providing instruction through this syllabus/curriculum has the opportunity to provide an educational setting which will enable students to explore their abilities and interests. Instruction could be provided to handicapped students either by teachers certified in this subject area or by special education teachers. Teachers certified in this subject area would be providing instruction to handicapped students recommended by the COH as being able to benefit from instruction in a regular educational setting. Special education teachers may also provide this instruction to a class of students with handicapping conditions in a special class setting.

Teachers certified in the subject area should become aware of the need of those students with handicapping conditions participating in their classes. Instructional techniques and materials must be modified to the extent appropriate to provide students with handicapping conditions the opportunity to meet diploma requirements. Information or assistance is available through special education teachers, administrators, the Committee on the Handicapped, or a student's IEP.

Special education teachers providing this instruction must also become familiar with the goals and objectives of the curriculum. It is important that these teachers provide their students with the same or equivalent information contained in the curriculum.

Regardless of who provides the instruction, the cooperation between teachers of regular and special education programs is essential. It is important for all students as well as for the total school environment.

Another consideration in assisting students with handicapping conditions to meet the requirements of regular education is the use of alternative testing techniques. Handicapped students may be provided alternative testing techniques on statewide tests and district testing programs. The consistent use of alternative testing techniques is important for providing handicapped students the opportunity to demonstrate their knowledge and skills without being limited by their handicapping condition.

Increasing Awareness of Persons with Disabilities

Throughout the development of the Action Plan, the Board of Regents reaffirmed a strong commitment to integrating the education of students with handicapping conditions into the total school program. In keeping with the concept of total integration, the following subgoal of the Action Plan was established:

> In all subject areas, revisions in the syllabi will include materials and activities related to generic subgoals such as problem solving, reasoning skills, speaking, capacity to search for information, the use of libraries and increasing student awareness of and information about the disabled.

The purpose of this subgoal is to ensure that appropriate activities and materials are available to increase student and teacher knowledge of disabilities. Frequently students, including those with handicapping conditions, are aware of only the differences between people with and without disabilities. Teachers, whatever the subject or content, have an opportunity to assist students in gaining an awareness of the similarities of all people, including those with disabilities.

This syllabus/curriculum, by design, includes information, activities, and materials regarding persons with handicapping conditions. Teachers are encouraged to include other examples as may be appropriate to their classroom or the situation at hand.

Teachers are also encouraged to assess the classroom environment to determine how the environment may contribute to student awareness of persons with disabilities. Are persons with disabilities represented in classroom displays and materials? Do books, games, posters, etc. portray children and adults with disabilities in a positive, nonstereotypical manner?

Also, teachers must be aware of the negative images inherent in some terms and avoid the use of such terms (crippled, afflicted, suffering, victim). The use of terminology which shows what people can do rather than what they can't do, and which portrays persons with disabilities accurately and positively should be reinforced and used consistently.

It is important for students to have an opportunity for contact with people with disabilities within their daily environment. Teachers can assist by using instructional materials that include information about children and adults with disabilities. Teachers may contact the local Special Education Training and Resource Center (SETRC) for ideas and specific resources for materials that portray persons with disabilities in a positive manner.